

Sacramento River Flood Control System Evaluation
Initial Appraisal Report - Upper Sacramento Area

Attachment B

**Basis of Design
Geotechnical Evaluation of Levees
February 1993**

C-103860

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**BASIS OF DESIGN
GEOTECHNICAL EVALUATION OF LEVEES
FOR
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION
UPPER SACRAMENTO AREA - PHASE V**

February 1993



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**GEOTECHNICAL EVALUATION OF LEVEES
FOR
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION
UPPER SACRAMENTO AREA - PHASE V**

A. INTRODUCTION.

The Upper Sacramento Area, Phase V, of the Sacramento River Flood Control System is located in the northern section of the Sacramento Valley region. The study area covers approximately 270 miles of project flood control levees along the Sacramento River and tributaries above Knights Landing. The levees in the study area are shown on the Index Map (Plate 1) and Location Maps (Plates 2-26). They include the west bank levee of the Sacramento River from Knights Landing upstream to Ordbend, the east bank levee of the Sacramento River from the Tisdale Bypass upstream to Glenn, a portion of Butte Slough, the west bank levee of Sutter Bypass, the north bank of Tisdale Bypass, and levees of Cherokee Canal, Butte Creek, Mud Creek, Deer Creek and Elder Creek.

In the spring of 1991, the California Department of Water Resources (DWR) performed a levee inspection which included interviews with local reclamation districts to determine where past levee problems have occurred. Several problems were identified in the DWR report. These included seepage, sand boils, stability, erosion, and low spots on the levees. Levee erosion problems are normally resolved under the Sacramento River Bank Protection Project. Only levee seepage, sand boils, and instability problems are identified in this report.

B. EXPLORATIONS.

A review of Corps files indicates there is no previous exploration data for the Sacramento River levees upstream from Knight Landing. However, previous explorations are available for four of the five tributaries in the study area. These include Cherokee Canal, Butte Creek, Mud Creek, and Elder Creek. These explorations were performed as part of design studies conducted between 1948 and 1960.

Foundation investigations were conducted between Glenn and Knights Landing from 30 March to 15 May 1992. These investigations include a total of 63 borings (2F-92-1 through 2F-92-32). Two holes were drilled at 32 locations, one hole on the levee crown and one hole with an "A" designation at the toe of the levee. A 6-inch-diameter hollow-stem flight auger was used to drill thirty-two 45-foot-deep holes and thirty-one 25-foot-deep holes. Standard Penetration Test (SPT's) were conducted using a 140-pound safety hammer free falling 30 inches. Sampling was continuous with SPT's to a depth of 20 feet and at 5-foot intervals thereafter. The resistance blow counts of the materials were obtained by using an 18-inch-long standard 2-inch O.D. by 1-3/8-inch I.D. split-spoon sampler. The borings were generally drilled in locations where past levee problems have been reported. This was done so that levee and foundation soil conditions could be evaluated in determining what, if any, remedial repairs should be accomplished at any levee reconstruction problem sites.

C. LABORATORY TESTING.

No previous laboratory data are available. Laboratory testing of samples collected during the 1992 exploration program were performed by the South Pacific Division Laboratory in Sausalito, California, during July and August 1992. These tests included visual classifications, Atterberg limits, and sieve analysis. The results of these tests were used to determine relative seepage potential characteristics. Fines content of soils determined from grain size analyses are shown in percent minus 200 sieve size on individual soil logs shown on the levee profiles Plates 27 through 49. Further discussion of laboratory testing is discussed as appropriate under each of the study reaches in the following paragraphs.

D. BASIS FOR EVALUATIONS.

This report identifies several sites for remedial repair. The selected sites and methods of repair are based in large part on engineering judgement. The actual levee profiles and topography are irregular, and the foundation soil conditions are highly variable in the upper Sacramento River levee system. Soil types and thicknesses of various soil deposits vary considerably within any given reach. Therefore, although some seepage and stability analyses were used in evaluating site specific conditions, conclusions are based largely on engineering judgement. This judgement is based on past performance, site conditions, and drill log data, as well as the seepage and stability analyses. Seepage-related problems have been identified in several levee reaches. Seepage can be a nuisance, but is not always considered a threat to levee stability. High exit gradient or seepage energy can, however, threaten levee stability. Therefore, the seepage sites identified for remedial repair in this study are those where seepage is considered a danger to levee stability. However, there is no guarantee that levee problems outside of the areas recommended for repair will not occur during floods or extremely high river stages. Surveillance during floods is therefore essential in maintaining integrity of the levee system. A total of 21 sites were identified as previous problem areas. Only two of these sites are recommended in this report for reconstruction. They are site 4 and site 11/12 (see Table 1, on page 18).

E. SACRAMENTO RIVER - WEST BANK LEVEE (Sacramento River West Side Levee District)

The levees in this reach include approximately 50 miles along the west bank of the Sacramento River (R.M. 90 to R.M. 143.5) and extend from Knights Landing upstream to Colusa, as shown on Plate 1. The levee in this reach is maintained by the Sacramento River West Side Levee District.

1. Explorations.

Explorations conducted during this study included 43 borings (2F-92-9 thru -14) and (2F-92-17 thru -32). Landside and waterside toe borings were drilled to a depth of 25 feet, and the levee crown borings were drilled to a depth of 45 feet. These borings were drilled at nine sites where seepage and sand boils have been reported during high river stages.

2. Levee and Foundation Conditions.

The levee and foundation profile is shown on Plates 27, 29, 31, 33, 35, 41, and 43. The levee cross sections are shown on Plates 26, 28, 30, 32, 34, 40, and 42. The waterside levee height ranges from approximately 7 to 18 feet, but is typically about 13 feet. The landside levee height ranges from approximately 11 to 20 feet, but is typically about 17 feet. The waterside slope varies from approximately IV on 2.4H to 4H and is typically about IV on 3H. The landside levee slope varies from about IV on 2H to 4H and is typically about IV on 2H. Levee crown width varies from approximately 15 to 50 feet, but is typically about 21 feet. Some sections of levee are paved highway, the rest of the levee is gravel surfaced. The levee soil is primarily sand, clayey sand, or sandy clay and silt. The foundation soils are composed of variable deposits of silt, sand, and clay. In general, the levee investigated in this reach appears stable and in good condition.

3. Past Performance.

Past problems along the west bank levee of the Sacramento River have generally been landside seepage and sand boils in several locations during high water. Nine past problem areas were identified. These are described below.

Site 1 is about 3 miles (15,700 feet) in length and extends from R.M. 92.7 upstream to 96.0 (Location, Plate 2, and Profile, Plate 27). See photos 1 and 2. It is located between Fourmile Bend and Victor Bend. This is a reported seepage area. However, during the field inspection, indications of past seepage in this area were not apparent. The levee soils in this area are composed predominantly of clean sand with fines content less than 12 percent. However, two banks failed during June 1992, approximately 8,000 feet south of site 1. The bank failure at R.M. 90.4 is about 110 feet in length, and the bank failure at R.M. 90.9 is approximately 225 feet in length. Existing vegetation has collapsed with the berm. What remains of the berm is the 10-foot fire break. The probable cause of these bank failures is seepage from the large landside irrigation ditch, which aggravated stability of the steep riverside berm. The seepage from the irrigation ditch in this area has saturated the foundation beneath the waterside berm and significantly decreased the shear strength of the underlying silty clay material, thereby triggering the berm failure. Full bank rock revetment was recommended and was constructed at R.M. 90.4 and R.M. 90.9 in late 1992 and early 1993.

Site 2, reported as a seepage area, is approximately 2.27 miles (13,100 feet) in length and extends from R.M. 103 upstream to R.M. 108 (Location, Plate 3, and Profile, Plate 29). See photos 3 and 4. Based on soil boring data and laboratory testing, the levee was constructed of clayey sand or sandy clay, silt, and silty sand or sandy silt from R.M. 105 upstream to R.M. 108. The levee was constructed of clean sand with a fines content between 5 and 7 percent from R.M. 105 downstream to R.M. 103.

Site 3 was identified as a 3-mile site beginning at R.M. 114 upstream to R.M. 117 (Location, Plate 4 and Profile, Plate 31). See Photos 5 and 6. Seepage was reported along this site. The levee material in this area consists of clean sand, silt, and sandy clay or clayey sand.

Site 4 was identified as a seepage site. It is approximately 5,180 feet in length, extending from R.M. 119 upstream to R.M. 120, and is located approximately 800 feet upstream from the confluence of the Tisdale Bypass (Location, Plate 6, and Profile, Plate 33). See Photos 7 and

8. The levee at this site was constructed of silt, sand, clay, and clayey sand.

Site 5 is about 2,500 feet in length and extends from R.M. 122.5 upstream to R.M. 123 (Location, Plate 6, and Profile Plate 35). See photos 9 and 10. This is a reported seepage area. The levee soils in this area consist of clayey sand or sandy clay. The foundation materials are mostly clay and clayey sand.

Site 9 was identified as a seepage site, about 5,150 feet in length, extending from about R.M. 126.5 upstream to R.M. 127.5, and is located about 4,000 feet upstream from the town of Grimes (Location, Plate 7, and Profile, Plate 35). See photos 11 and 12. The levee material in this area generally consists of clean sand (fines content ranges between 5 and 10 percent) and silty sand.

Site 10 is a seepage area, about 1,500 feet in length, extending from R.M. 134.2 upstream to R.M. 134.5, beginning approximately 800 feet upstream from the Meridian Bridge (Location, Plate 10, and Profile, Plate 41). See photos 13 and 14. There is an irrigation ditch in this reach about 3.5 feet in depth and 14 feet in width running along the landside toe. The levee material in this area consists of clay and clayey sand or sandy clay.

Site 11 is an area of seepage between R.M. 140 and R.M. 141. It is approximately 5,000 feet in length, beginning 1.2 miles upstream from Moons Bend (Location, Plate 10, and Profile, Plate 43). See photos 15 and 16. Sand boils were reported at a number of separate places at this site. Based on soil boring data and laboratory test results, the levee was constructed of clean sand from R.M. 140.5 upstream to site 12. The riverside berm in this area is only 5 feet wide. The levee was constructed of clay, clayey sand or sandy clay, from R.M. 140.5 downstream to Moons Bend. There is extensive rodent activity on the waterside slope in this area.

Site 12 is an area of seepage that extends from about R.M. 142.5 upstream to about R.M. 143.2 and is approximately 3,400 feet in length (Location, Plate 11, and Profile, Plate 43). See Photos 17 and 18. Some small boils have occurred near the upper end of this site. The levee soils in this area are composed predominantly of clean sand. A small irrigation ditch running along the landside toe, beginning approximately 4,200 feet downstream from the Colusa Bridge, turns away from the levee at the end of this site.

4. Conclusions and Recommendations.

Although seepage and some sand boils were reported at site 12 during high water, the performance of Sacramento River West Side Levee District levees has been good. The few cases of seepage that have been reported were mostly generalized seepage over relatively large areas.

The levee at Site 1 consists of loose sand. This material is susceptible to seepage. However, based on levee geometry, this levee section is not considered critical. The levee crown width is quite large varying from approximately 23 to 50 feet. The landside slope is relatively flat at IV on 2.4H to 2.7H at boring locations 2F-92-30, -31 and -32 (Photos 1 and 2). The levee foundation soil along this area consists mainly of silt and clay. It is believed that the seepage in this area is primarily of nuisance variety and does not pose any major risk to levee stability. Therefore, no reconstruction is recommended at this site.

Site 2 was identified as a seepage site. Exploration data indicate levee conditions are susceptible to seepage. As can be seen on the levee profiles on Plate 29, the levee soil consists primarily of clean sand (boring 2F-92-28 and 2F-92-29). At the locations where the levee soil is primarily clean sand, the landside slope varies from about IV on 3.5 to 4.1H (Photos 3 and 4).

The foundation materials are clay and silt. Some sand layers that may have been missed by the explorations would account for some of seepage. In conclusion, although seepage does occur in this area during high water, it is believed that overall stability of this site is adequate and no reconstruction measures are necessary.

Site 3 was reported as a seepage site. Again, the levee material consists of clean sand. However, the landside slope is relatively flat at IV on 2.2H to 2.7H (Photos 5 and 6). The freeboard at this location is 6 to 9 feet. During flood conditions, the head differential between the river and the landside toe is a maximum of about 10 feet. Although seepage may occur in this area, it does not pose any significant threat to the levee stability. Therefore, no repairs are recommended at this location.

Stability analyses were performed at Site 4. The resulting minimum factor of safety was 1.42, which is above Corps criteria. However, the maximum levee height is approximately 16 feet, with a landside slope of IV on 2H to 2.2H (Photos 7 and 8). Levee and foundation soils are predominantly sand at boring location 2F-92-22. The freeboard at this location is estimated to be about five feet. During flood conditions, the head differential between the river and the landside toe is a maximum of about 11 feet. There is sufficient concern for levee stability in the vicinity of boring 2F-92-22 to warrant construction of a landside seepage/stability berm. The levee material at boring location 2F-92-20 and 2F-22-21 consists of sand, clay, and clayey sand and the levee height is lower (12 to 14 feet). Therefore, it is recommended that a seepage/stability berm (Figure A-1) be constructed in the area along boring 2F-92-22, as shown on Plate 33. The berm will improve overall stability of the levee and decrease the potential for foundation piping.

Site 5 was identified as being a short reach with seepage-related problems. The levee and foundation soils along this site are primarily clay, sandy clay, and silt. During the field inspection, any indications of past seepage in this area were not apparent, and the overall appearance of this reach appears structurally sound (Photos 9 and 10). Therefore, there are no recommendations for reconstruction for this site.

The levee soils at Site 9 are predominantly loose and clean sand. The landside slope is relatively flat at IV on 2.4H to 2.7H at boring locations 2F-92-17, and 2F-92-18 (Photos 11 and 12). During flood conditions, the head differential between the river and the landside toe is only about 8 feet. No signs of slope instability were noted during the field inspection. Stability analyses were performed, and the resulting factor of safety was 1.52, which is above Corps criteria of 1.4. No reconstruction is recommended at this location.

The levee at Site 10 is relatively low at about 12 feet in height, with a flat landside slope of approximately IV on 2.2H (Photos 13 and 14). The reported seepage at this reach appears to be in an irrigation ditch immediately adjacent to the levee toe. The seepage is not considered critical, and no boils were reported in the irrigation ditch. Therefore, no reconstruction is considered necessary at this site.

The levee between Site 11 to Site 12 is considered highly susceptible to damage during floods. Seepage and sand boils along the landside toe during the 1986 flood indicates a potentially unstable condition. The maximum height of levee along this area is approximately 19 feet, with a landside slope of IV on 1.8H to 2.5H (Photos 15 through 18). As indicated on the levee profile on Plate 43, the levee and foundation soils are predominantly sand. Therefore, it

is recommended that a landside seepage/stabilizing berm be constructed (See Figure A-1). The berm will not reduce the overall quantity of seepage, but it will improve the stability of the levee and decrease the potential for piping of foundation sand.

F. SACRAMENTO RIVER - WEST BANK LEVEE (Maintenance Area 1)

This reach includes approximately 17 miles along the west bank of the Sacramento River and extends from the town of Colusa upstream to the Colusa-Glenn County line, as shown on Plate 1 (R.M. 143.5 to R.M. 164.5). The levee in this reach is maintained by Sutter Yard, Maintenance Area 1 of the California Department of Water Resources.

1. Explorations.

Explorations conducted during this study included six borings (2F-92-6 thru -8). Landside and waterside toe borings were drilled to a depth of 25 feet, and the levee crown borings were drilled to a depth of 45 feet. These borings were drilled in locations where seepage and boils have been reported during high river conditions (Site 16). These conditions are described in the following paragraphs.

2. Levee and Foundation Conditions.

The levee and foundation profiles are shown on Plates 43 and 45. The levee cross sections are shown on Plate 46. The levee in this reach of Sacramento River typically ranges in height between 7 to 20 feet, but is typically about 14 feet. The levee crown width varies from 10 to 20 feet and is typically about 18 feet. The levee crown is gravel surfaced and in excellent condition. Landside and waterside slopes are variable, typically ranging between 1V on 2H to 3H. Borings 2F-92-7 and -8 indicate the levee materials consists of loose sand, while the foundation soils are composed of variable deposits of clay, silt and clayey sand, or sandy clay.

3. Past Performance.

The 17-mile levee reach along the west bank of Sacramento River has performed well. Two sites were identified as having seepage problems. These are described below.

Site 13 is about 1,600 feet in length (Location, Plate 11, and Profile, Plate 43). It is located in the town of Colusa between 5th and 9th Streets. The levee in this area was set back many years ago to its current position between River Street and Main Street. The waterside bank has eroded away as the river moved closer to the levee over the years. The old buildings on Main Street have cellars, some of which collect water during high stages. Old tunnels and galleries that used to run under Main and River Streets to the docks on the river are not known to have been properly backfilled. The portal of at least one of these tunnels, now bricked up, still exists in the basement of one building (Hog Heaven) and produces seepage during high stages.

Site 15 is approximately 3,800 feet in length, extends from R.M. 154.8 upstream to R.M. 156.2 (Location, Plate 12, and Profile, Plate 45). This is an area of considerable seepage when high stages continue for extended periods. In 1983 seepage was particularly bad, causing closure of Highway 45 until CALTRANS started pumping the water into a nearby ditch leading to Colusa Trough.

4. Conclusions and Recommendations.

The levee along Site 13 is only about 12 feet high, and landside slope is relatively flat at approximately IV on 2.2H. The riverside berm is protected by stone. During the field inspection, no visible signs of seepage were detected. It is believed that the seepage in this area is a nuisance, but does not pose any major risk to levee stability. No repairs are recommended at this site.

Site 15 was identified as experiencing heavy seepage during high water. Based on available drill logs, the levee and foundation soils are not susceptible to excessive seepage. The levee and foundation material is primarily clay, sandy clay, and silt. During the field inspection, there were no indications of past seepage in this area. There is no recommendation for reconstruction for this site.

G. SACRAMENTO RIVER - WEST BANK LEVEE (Glenn Co. L.D. 1 and L.D. 2)

This reach includes approximately 17 miles along the west bank of the Sacramento River and extends from the Colusa-Glenn County line upstream to Ordbend, as shown on Plate 1 (R.M. 164.5 to R.M. 184). Glenn County Levee District No. 1 maintains the upper portion of this reach (5 miles). Glenn County Levee District No. 2 maintains lower portion of this reach (12 miles).

1. Explorations.

Explorations performed during this study included a total of 10 borings (2F-92-1 thru -5). These borings were drilled at two different sites where seepage has been reported during high river conditions. Landside and waterside toe borings were drilled to a depth of 25 feet, and the levee crown borings were drilled to a depth of 45 feet.

2. Levee and Foundation Conditions.

The levee and foundation profiles are shown on Plates 47 and 49. The levee cross sections are shown on Plates 48 and 50. The levee in this reach of the Sacramento River varies from 5 to 16 feet in height. The levee is higher at the southern end, but is typically about 14 feet high. The levee slopes are typically IV on 1.4H to 2H landside and IV on 2.1H to 3.2H on the waterside. The levee crown width varies from 15 to 40 feet and is typically about 18 feet wide. A portion of the levee crown is paved and a portion is gravel surfaced. Based on available exploration data, the levee material consists of clay and sandy clay. The foundation material at Sites 16 and 19 consists of clay. At Site 19 sand exists at a depth of about 14 to 20 feet below the clay.

3. Past Performance.

Past problems along this reach of the Sacramento River have generally been landside seepage. Five past problem areas were identified. Site 16 thru 18 are maintained by Levee District No. 2, and Site 19 is maintained by Levee District No. 1. These are described below.

Site 16 begins at the Glenn-Colusa County line and extends approximately 9,500 feet upstream (Location, Plate 13, and Profile, Plate 14). See Photo 19. This is an area of seepage that reportedly develops when the river is at high stages for several days. Seepage occurs in the irrigation ditch that parallels the road in this reach. It also occurs in the field away from the

levee. During extended periods of high flow, the effects of high water are reportedly apparent several miles out into the field. It was reported that at least one well about 2 miles from the levee becomes artesian at these times.

Approximately 600 feet north of Site 16, past seepage has been reported adjacent to the 4-inch-diameter cast iron pipe through the levee (Photo 20). The pipe is highly corroded and penetrates the levee at a point below the design flood level. The pipe was apparently used in past years for irrigation. It appeared to be abandoned. For several reasons, including the susceptibility of the levee soils to seepage and piping and the deteriorated condition of the pipe, the pipe should be removed and the levee soils recompacted adjacent to the excavation created during removal of the pipe.

Site 17 was identified as an area of heavy seepage, beginning just south of Highway 162 and extending approximately 1,700 feet downstream (Location, Plate 13). During high river stages, water reportedly flows out of the ground between the levee and the highway. During the field inspection, extensive rodent holes were found on the landside of the levee just north of Highway 162.

Site 18 is located approximately 1,700 feet north of Highway 162. At this location a new ditch has been dug perpendicular to the levee (location, Plate 14). The ditch is about 10 feet wide and 10 feet deep and intercepts a sand layer. A portion (90 feet) of this ditch has been backfilled. A number of swales that are up to several hundred yards from the levee typically fill with water during high river stages.

Site 19 is about 2,000 feet in length and is approximately 5,200 feet south of the town of Glenn (Location, Plate 14, and Profile, Plate 49) see Photos 21 and 22. This is a location of reported seepage that occurs when the river has been up for several days. The river is some distance from the levee in this reach, and the levee only has water against it during high flows. During events such as 1986, and particularly 1983, significant seepage was reported in the field between the levee and the highway, and the field becomes too soggy for agricultural operations.

4. Conclusions and Recommendations.

Site 16 is a location where seepage flows into a drainage ditch adjacent to the levee toe. This reach of levee is a paved highway with a very large crown width, approximately 40 feet (Photo 19). The levee and foundation material consists mostly of clay, and there does not appear to be a high potential for piping. It is likely that the drainage ditch intercepts some seepage during high water. No repairs are recommended at this site.

North of Site 16, seepage has been reported adjacent to the 4-inch diameter cast iron pipe through the levee (Photo 20). The pipe should be removed and the levee recompacted with native material. It is recommended that this measure be undertaken by the Glenn County Levee District No. 2.

Site 17 was reported as a seepage area. During the field inspection, there were no indications of past seepage. It is believed that the seepage in this area is generalized seepage that does not pose any threat to the levee. Therefore, no repairs are recommended at this site.

Site 18 is a site where a ditch had been dug perpendicular to the levee. During the field inspection, it was observed that a portion of the ditch was backfilled. If seepage-related problems still occur in this ditch, it is recommended the entire ditch be backfilled. This reach

of the study area has performed without any other problems. Therefore, there are no recommendations for reconstruction for this area.

Site 19 was identified as an area of significant seepage that occurs when the river has been up for several days. The levee along this reach is relatively low, varying from 9.3 to 11.3 feet, with a flat landside slope of IV on 2.3H (Photos 21 and 22). Based on the exploration data and levee geometry, it is believed the levee in this reach is stable. A levee underseepage analyses at this site resulted in a seepage exit gradient of 0.46. Engineering guidelines suggest a seepage berm where the exit gradient exceeds 0.50. Therefore, no reconstruction is recommended in this reach.

H. SACRAMENTO RIVER - EAST BANK LEVEE (Glenn County Levee District No. 3)

The levee in this reach extends for approximately 12 miles along the east bank of the Sacramento River and extends from Glenn-Colusa County line upstream to approximately 2,000 feet north of the Butte-Glenn County line, as shown on Plate 1 (R.M. 162 to R.M. 176). The levee in this reach is located in Glenn County and maintained by the Glenn County Levee District No. 3.

1. Explorations.

There is no record of explorations in this reach of levee.

2. Levee and Foundation Conditions.

A typical levee cross section for this reach is shown on Plate 13. The levee in this reach of Sacramento River ranges in height from 9 to 16 feet, but is typically about 12 feet high. The levee crown width varies from 10 to 20 feet and is typically about 18 feet. The levee crown is gravel surfaced and in excellent condition. The waterside slope varies from approximately IV on 3H to 4H, but is typically about IV on 3H. The landside slope varies from about IV on 2H to 2.5H, but is typically about IV on 2H. Levee and river bank erosion has been reported at two sites. The first site begins approximately 1,800 feet north of the Glenn-Colusa County line and extends 2,500 feet upstream. The levee in this area sustained erosion damage during the 1986 flood. The rather long fetch across open water and heavy south winds while water was up against the levee caused the erosion damage. The second site is about 2,600 feet in length and extends from R.M. 167.8 to 168.3. At this location, the river is eroding the bank. While not a serious problem at this time, there is concern about the effect on the levee in the future if this erosion continues.

3. Conclusions and Recommendations.

In general, the existing condition of the levee in this reach is good and the levee appears stable. Bank protection should be provided in this reach where erosion is active. There are no recommendations for reconstruction in this reach.

I. SACRAMENTO RIVER - EAST BANK LEVEE (East Levee Sacramento River)

This reach includes approximately 20 miles along east bank of the Sacramento River and extends from the confluence of the Butte Slough outfall gates to the Glenn-Colusa County line, as shown on Plate 1 (R.M. 138.2 to R.M. 162). The levee in this reach is maintained by the California Department of Water Resources.

1. Explorations.

There is no record of explorations in this reach of levee.

2. Levee and Foundation Conditions.

A typical levee cross section for this reach is shown on Plate 12. The levee in this reach of Sacramento River typically ranges in height from 9 to 19 feet, but is typically about 13 feet. The levee crown width varies from 14 to 26 feet and is typically about 18 feet. A portion of levee crown is paved and the rest is gravel surfaced. Levee slopes appear to be uniform throughout this reach at IV on 2H on the landside and a IV on 3H on the waterside.

3. Conclusions and Recommendations.

The levee in this reach appears to be in good condition. It is well maintained, with no sign of erosion, settlement, or instability. No problems of were reported for this reach of levee in the past, and there are no recommendations for reconstruction.

J. SACRAMENTO RIVER - EAST BANK LEVEE; BUTTE SLOUGH - WEST BANK LEVEE (R.D. 70)

The levee in this reach covers the northern Sutter Basin and includes approximately 24 miles and is maintained by the Reclamation District 70. These levee include the east bank of the Sacramento River from the confluence of Butte Slough to 15.6 miles downstream. The west bank of Butte Slough extends from the Sacramento River to Sutter Bypass and is approximately 8 miles in length, as shown on Plate 1.

1. Explorations.

Explorations conducted during this study included four borings (2F-92-15 through -16). See Plate 9. Landside and waterside toe borings were drilled to a depth of 25 feet, and the levee crown borings were drilled to a depth of 45 feet. Borings 16 and 16A were drilled where sand boils have been reported during high river conditions.

2. Levee and Foundation Conditions.

The levee along west bank of Butte Slough varies from 15 to 19 feet in height, with an 18 to 22-foot crown width, a IV on 1.8H to 3H slope on the landside, and IV on 2.2H to 3.3H slope on the waterside. The levee and foundation profile is shown on Plate 39. The levee cross sections are shown on Plate 40. Based on available exploration data, the levee and foundation soils along the west bank of the Butte Slough are composed of variable deposits of silt, clay and sandy clay.

The levee along the east bank of Sacramento River varies from 10 to 22 feet in height, with

22 to 33-foot crown width, a 1V on 2H slope on the landside, and a 1V on 2.2H to 3H slope on the waterside. Approximately half the levee crown is a paved highway and the rest is gravel surfaced.

3. Past Performance.

The 15.6 miles of levee along the east bank of the Sacramento River has performed well with no reported problems. However, several problem areas have been reported in the past along the west bank levee of Butte Slough. These are described below.

Site 6 is the site of the 1940 break in the levee located near levee mile 4.2 (Plate 9). It has been reported that the scour hole from this break has water in it year around and produces significant seepage during high flows.

Site 7 is about 500 feet in length and located near levee mile 3.4 (Location, Plate 9, and Profile, Plate 39). A number of small boils have occurred near the levee toe and in the adjacent orchard. In 1986, these boils were monitored but did not require flood fighting measures such as sandbag chimneys.

Site 14 is the site of a sinkhole 10 to 15 feet in diameter located near levee mile 6.7 (Plate 10). This sink hole reportedly occurred for no apparent reason during a summer low water period. The site was excavated for exploration and then backfilled and compacted with native material.

4. Conclusions and Recommendations.

Site 6 is the site of a 1940's levee breach. A large scour pond remains approximately 170 feet from the levee toe. It is likely that seepage from Butte Slough enters into the pond. The landside slope is relatively flat at 1V on 2.5 to 2.8H. No repairs are recommended at this location.

Site 7 was identified as a site where a number of small boils have occurred in the past. Based on available exploration data, the levee material consists of silt and sandy silt. The foundation soils are composed of silt, clay, and clayey sand. There is a sand layer about 30 feet below the natural ground surface. The landside slope at this site is relatively flat at about 1V on 2.8H (Photo 23). No indication of past boils or seepage were evident during field inspection. No reconstruction is recommended for this site.

- During field inspection, a depression was noted at the waterside levee toe near levee mile 7.1 (Photos 24 and 25). This depression is 3 feet deep and 9 to 11 feet in diameter and appears to have occurred recently. It is recommended that Reclamation District 70 excavate backfill and compact the depression with native material.

K. SUTTER BYPASS - WEST BANK LEVEE; TISDALE BYPASS - NORTH BANK LEVEE SACRAMENTO RIVER - EAST BANK LEVEE (R.D. 1660)

The levee covered in this reach is located in Sutter County and is on the west bank of Sutter Bypass and extends from the beginning of Sutter Bypass downstream to the intersection with Tisdale Bypass, north bank of Tisdale Bypass, and a portion of east bank of Sacramento River extending from Tisdale Bypass approximately 3 miles upstream (Plates 5, 6, and 8). The levee in this reach is approximately 17 miles in length and is maintained by Reclamation District 1660.

1. Explorations.

Prior to this study, 23 explorations were performed along the west bank of Sutter Bypass. These were borings 2F-3 through -10 drilled in April 1956, borings 2F7-51a-1A, 2F7-51a-1 through -12 drilled in July 1957, and borings 2F8-1 and 2F8-18 drilled in April 1958. These borings were drilled along the landside levee toe where seepage and boils have been reported during high flood stages. Most of these borings were drilled to a depth of 20 feet.

2. Levee and Foundation Conditions.

The levee and foundation profiles are shown on Plate 37. The levee cross sections are shown on Plate 38. The Sutter Bypass levee is typically about 24 feet in height with a 15- to 20-foot crown width, a IV on 2H slope on the landside, and a IV on 3H slope on the waterside (Photos 26 and 27). The waterside slope of the levee is rock revetted. There is a 50-foot-wide berm between landside toe and an irrigation ditch. The west Sutter Bypass levee was raised by the Sacramento District in 1941. Based on available borings, the foundation consists of a 4- to 5-foot clay layer on top of a 2- to 5-foot layer of hardpan. Beneath the hardpan is alluvial clay with silt and sand layers. Pervious sand and silt layers generally occur within 5 to 10 feet of the surface.

The levee on the north bank of Tisdale Bypass is typically about 21 feet in height with a very wide levee crown of approximately 75 feet. The levee slopes are typically IV on 2H waterside and IV on 3H landside. The Sacramento River levees in this reach are generally 9 to 15 feet in height with 14- to 33-foot crown widths, a IV on 2H slope on the landside and IV on 3H slope on the waterside.

3. Past Performance.

The levees of the north side of Tisdale Bypass and Sacramento River are generally in good condition with no problems reported. Most of the reported problems are along the west bank of Sutter Bypass. The problem area extends from MaClatchy Road south to Tisdale Bypass, about 5 miles. This area has a history of heavy seepage and boils. The high flood stages in the bypass and subsequent underseepage caused sand boils and heaving ground along the landside levee toe. These sand boils and ground upheaval occurred in December 1955, February 1958, December 1964, and January 1970.

- During 1955, a total of 14 relief drain wells were installed along the west levee to control the boils and ground upheaval. However, subsequent seepage conditions indicated that the relief wells were inadequate to control the boils. Therefore, in 1970, a gravel relief trench was installed in two different reaches along the west Sutter Bypass levee to control underseepage pressure. Reach 1 is 2 feet wide and 10 feet deep and extends from Oswald Road to 13,800 feet south. Reach 2 is 2 feet wide and 17.5 feet deep, and extends from Oswald Road to 8,000 feet north. This treatment seems to have cured the problem in both areas.

4. Conclusions and Recommendations.

The levee along the west bank of Sutter Bypass has a long history of heavy seepage and boils. However, since the construction of the relief trench, there have been no reports of boils or ground heaving in the repaired reach. Clear seepage does occur during periods of high water

in the Bypass. Therefore, the fix in this area is considered to be performing as designed. During the field inspection there were no signs of recent seepage or boil activity. In general, the levee along the west bank of Sutter Bypass appears to be substantially stable, and there are no recommendations for reconstruction in this reach.

L. CHEROKEE CANAL (Maintenance Area No. 13)

Cherokee Canal, Maintenance Area 13 is east of Oroville in Butte County, California (Plates 16 through 19). The levees include both banks of Cherokee Canal and extends from Colusa Highway upstream to Highway 99, approximately 41.6 miles. The Cherokee Canal levees are maintained by Sutter Yard of the California Department of Water Resources.

1. Explorations.

Twenty-two borings (2F8-1 through 2F8-22) were performed by the Corps of Engineers in May 1958 along both banks of Cherokee Canal. Landside and waterside toe borings were drilled to a depth of 10 to 18 feet, and the levee crown borings were drilled to a depth of 20 to 35 feet. No new explorations were conducted during this study.

2. Levee and Foundation Conditions.

Based on available exploration data, the levee soils along the Cherokee Canal are primarily sandy clay and sandy silt. The foundation materials consist of varying combinations of sand, sandy clay, sandy gravel, clay, and silt. A typical levee cross section is shown on Plate 16. The levee height varies from approximately 3 to 10 feet. The levee slopes are typically IV on 2H waterside and 1V on 2.5H to 3H landside (Photo 28 and 29).

3. Past Performance.

Several problem areas have been reported in the past along the Cherokee Canal levee. Site 20 is on the left bank levee at approximately levee mile 21 (Plate 16). A slip 100 to 150 feet long occurred on the landside slope in 1986. In 1983, another similar slip occurred downstream about one-tenth of a mile. Both slips were repaired by Sutter Yard forces. Site 21 is on the right bank just downstream from an old Sacramento Northern railroad grade crossing (Plate 19). At this location, approximately 0.4 mile does not have levee and overtopped in March 1989.

4. Conclusions and Recommendations.

Although some levee slips were reported in the past, the overall performance of the Cherokee Canal levees has been good. Most of the problem areas are small and considered a maintenance responsibility and not considered a potential threat to levee stability. If site 21 is not up to the design height, it should be raised.

M. BUTTE CREEK (Maintenance Area No. 5)

Butte Creek, Maintenance Area S is located in Butte County, California (Plates 20 through 22). The levees are on both banks of Butte Creek and are approximately 33 miles long. It begins about 3 miles southeast of Chico and extends to about 4 miles east of the town of Afton. The Butte Creek levees are maintained by Sutter Yard of the California Department of Water

Resources.

1. Explorations.

Prior to this study, 30 explorations were performed along both banks of Butte Creek levees. These were borings 2F-3, 2F-9 through -17, and 2F-25 through -35 drilled in July 1948, borings 2F-3A and 2F-4A drilled in June 1949, and borings 4B-8, 2F-1 through -8 drilled in 1953.

2. Levee and Foundation Conditions.

A typical levee cross section is shown on Plate 20. The Butte Creek levees range in height from approximately 5 to 10 feet. The levee crown width are variable, typically ranging from 10 to 15 feet wide. Slopes as measured during the field investigation vary from about IV on 2H to 2.9H landside, and IV on 2.4H to 3.3H waterside (Photo 30). Based on an available exploration data, the levee material consists of sandy clay, clayey silt, or silty clay. The foundation consists of varying combinations of sand, clayey sand, sandy silt, clay, and silt.

3. Past Performance.

No seepage, sand boils, or levee stability problems have been reported for the Butte Creek levees. Based on the California Department of Water Resource reconnaissance report, both the Midway Road and railroad crossings are at lower elevations than the adjacent levee. However, no problems have been reported at these sites. The railroad bridge also requires cleaning of debris after every high water. This work is carried out by railroad personnel as necessary.

4. Conclusions and Recommendations.

Overall, the Butte Creek levees appear to be in good condition, are well maintained, and have no sign of seepage or erosion. At the reported low areas the levee elevation should be checked.

N. MUD CREEK AND SYCAMORE CREEK (Butte County Public Works)

Mud Creek and Sycamore Creek are in northwest Chico, Butte County, California. The levees are on both banks of Mud Creek and Sycamore Creek and are approximately 22.5 miles in length (Plates 23 and 24). The Mud Creek and Sycamore Creek levees are maintained by Butte County Public Works.

1. Explorations.

Thirteen explorations were performed along the Mud Creek and Sycamore Creek levees prior to this study. These were borings 2F7-16, -18, and -19, drilled in December 1957, and borings 2F-60-6, -7, -8, -11, -12, -15, -18, -19, -21, -22, drilled in June 1960.

2. Levee and Foundation Conditions.

The Mud Creek and Sycamore Creek levees vary from 5 to 10 feet in height, with 10- to 12-foot crown width, a IV on 3H slope on the waterside and a IV on 2H slope on the landside (Photos 31 and 32). The foundation soils along Mud Creek consist generally of a firm to stiff sandy clay (CL) and fat clay (CH) to depths of 5 to 15 feet. Below this layer the material

generally consists of a compact, slightly cemented sandy silt (ML). The foundation materials along Sycamore Creek consist of a firm sandy silt (ML) with average depth of about 3 feet. Below this layer, materials consist of sandy gravel, silt or fat clay.

3. Past Performance.

The levees of Mud Creek and Sycamore Creek are generally in good condition with no problems reported. The sediment does have a tendency to build up at some locations in the system and reduce flow capacity. The California Department of Water Resources is responsible for sediment removal, and so far no problems have developed.

4. Conclusions and Recommendations.

Mud Creek and Sycamore Creek levees appear to be in good condition and very well maintained. No recommendations are made for these levees.

O. DEER CREEK (Tehama County Public Works)

Deer Creek is located near the town of Vina, Tehama County, California. Four sections of the levees ranging in length from 0.5 mile to 5 miles make up the flood control system totaling approximately 7 miles in length (Plate 25). The Deer Creek levees are maintained by Tehama County Public Works.

1. Explorations.

There is no record of any explorations for the Deer Creek levees.

2. Levee and Foundation Conditions.

The levee cross section is shown on Plate 25. The Deer Creek levee typically ranges in height between 3 to 12 feet. The levee crown width is typically 12 feet. The levee slopes are typically IV on 2H waterside and IV on 3H landside (Photo 33).

3. Past Performance.

The levees were originally constructed in 1948, but were repaired by the Corps of Engineers in 1983 and Tehama County in 1985. During the 1986 flood, there were three levee breaches along the left bank levee and two eroded sites on the right and left bank. The damaged levee was repaired by the Corps of Engineers. Since 1986, the California Department of Water Resources has excavated large amounts of sediment from the channel. This material has been spoiled between the levee and the creek channel, with the top of the spoil pile being about the same elevation as the crown of the levee.

4. Conclusions and Recommendations.

Overall, the existing condition of the levee appears stable, with no sign of seepage or erosion. Therefore, no reconstruction is recommended for the Deer Creek levees.

P. ELDER CREEK (Tehama County Public Works).

Elder Creek is near the town of Gerber, Tehama County, California. The levees are on both banks of Elder Creek and are approximately 8 miles in length (Plate 26). The levees begin about 1.25 miles upstream from the confluence of Elder Creek and the Sacramento River and extend to I-5. The Elder Creek levees are maintained by Tehama County Public Works.

1. Explorations.

Prior to this study, three explorations were performed along the Elder Creek levees. These were borings 2B9-1, 2F9-1, and 2F9-2, drilled in August 1959.

2. Levee and Foundation Conditions.

A typical levee cross section is shown on Plate 26. The Elder Creek levees typically range in height between 3 to 7 feet. The levee crown width is typically 12 feet. The landside and waterside slopes are variable and range from approximately 1V on 2H to 3H (Photos 34 and 35). The foundation soils from the surface to a depth of about 8 feet are relatively impervious, consisting predominantly of sandy clay and sandy silt. Below 8 feet are discontinuous layers of pervious materials such as silty sand and sandy gravel.

3. Past Performance.

During the high water of February 1958, the locally constructed levee experienced erosion and seven levee breaks varying from 30 to 250 feet in length. These failures were caused by overtopping and erosion. The Elder Creek levees were reconstructed by the Sacramento District in 1959. It was reported that during the high water of 1986, levee overtopping occurred at the Southern Pacific Railroad Bridge. The levee overtopped at the south bank due to debris at the bridge. The other problem area is located at the lower end of the Elder Creek levees where overtopping can occur during high stages. Depending upon stages in the river versus stages in the creek, river water can overtop the levees. Also, sediment tends to build up in this reach of Elder Creek when backwater from the river slows velocities in the creek.

4. Conclusions and Recommendations.

During the field inspection the Elder Creek levee appeared to be stable, in good condition, and well maintained with no sign of erosion or settlement. The problems reported above are considered a local maintenance responsibility. It is concluded that no reconstruction is needed for the Elder Creek levees.

REFERENCES

1. U.S. Army Corps of Engineers, South Pacific Division Laboratory, Sausalito, California, "Report of Soil Test - Sacramento River, Flood Control System Evaluation, Upper Sacramento River, Phase V," July 1992.
2. U.S. Army Engineer District, Sacramento Corps of Engineers, Embankment Design Section, Foundations & Materials Branch, "Office Report, Underseepage, West Levee, Sutter Bypass, Reclamation District 1660," March 1970.
3. Department of the Army, Office of the Chief of Engineers, Washington, D.C. 20314, "Engineering and Design, Design and Construction of Levees", EM 1110-2-1913, March 1978.
4. U.S. Army Engineer Waterways Experiment Station, "LEVEEMSU: A Software Package Designed For Levee Underseepage Analysis", September 1989.
5. The California State Department of Water Resources "Corps of Engineers Levee Inspection Report, Phase V", Spring 1991.

TABLE 1

SUMMARY OF RECOMMENDED RECONSTRUCTION

SITE	RECOMMENDED RECONSTRUCTION	LENGTH
Site 4	Seepage/Stability Berm	0.51 mile (2700 ft)
Site 11/12	Seepage/Stability Berm	2.68 miles

**BASIS OF DESIGN
GEOTECHNICAL EVALUATION OF LEVEES
FOR
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION
UPPER SACRAMENTO AREA - PHASE V**

PHOTOGRAPHS

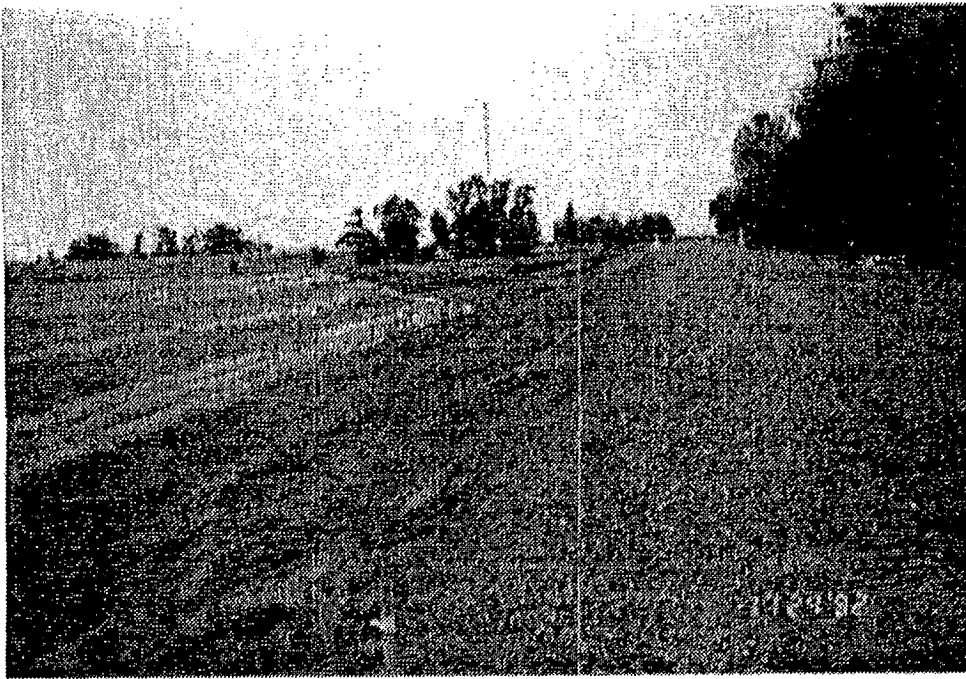


Photo 1: Site 1 - Landside slope just upstream of boring 2F-92-31.
(Nov 24, 1992)



Photo 2: Site 1 - Looking upstream along waterside slope from boring 2F-92-31.
(Nov. 24, 1992)

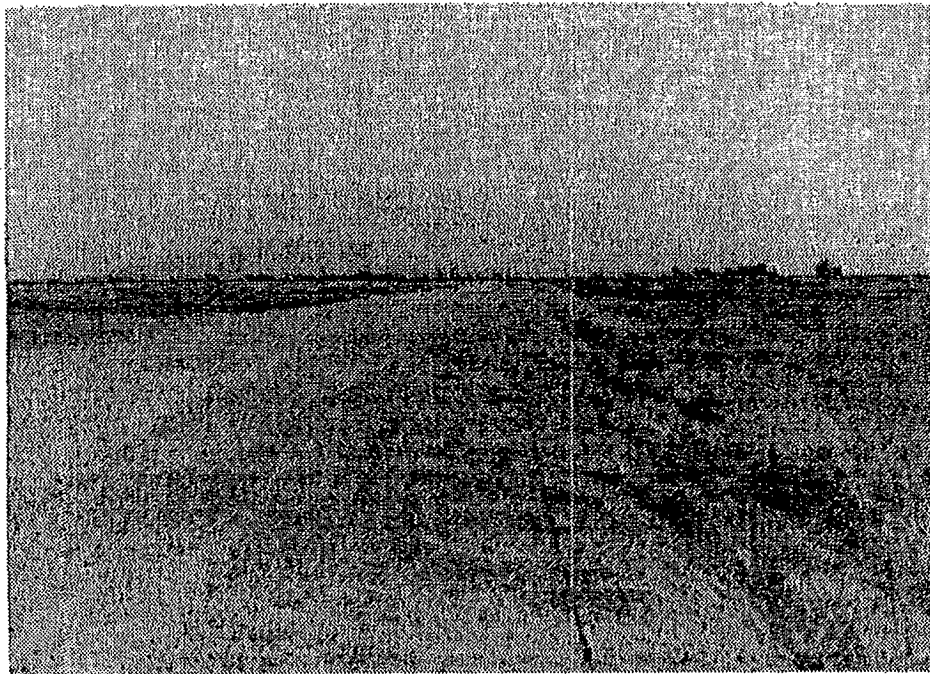


Photo 3: Site 2 - Looking upstream along riverside slope near boring 2F-92-2. (April 27, 1992)



Photo 4: Site 2 - Typical levee at this site. Looking downstream along lands ide slope near boring 2F-92-27. (April 27, 1992)

Figure 1

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4 8 3 0 1 - C

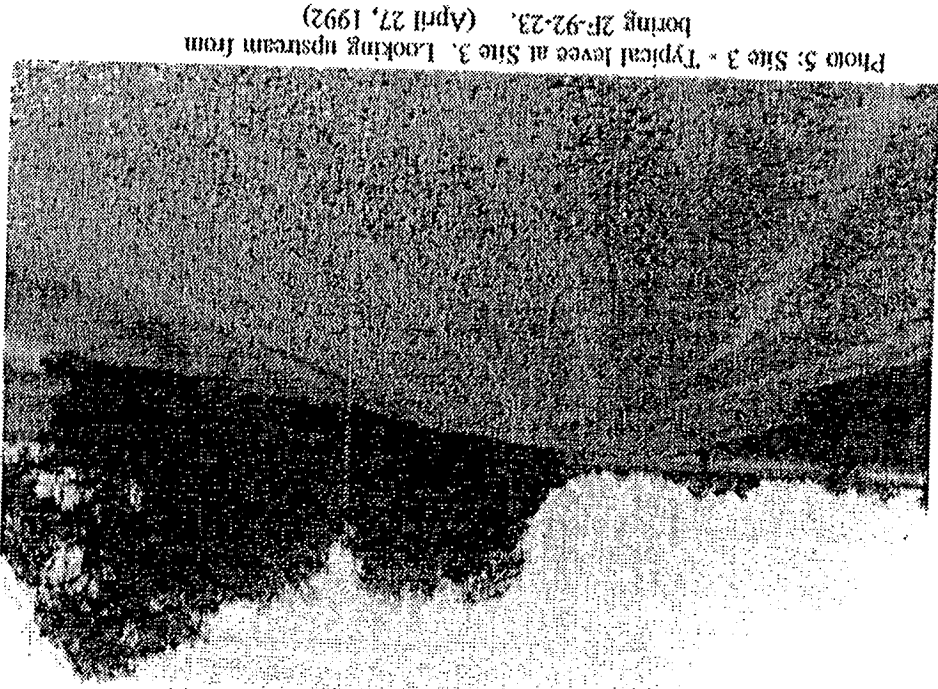


Photo 5: Site 3 - Typical levee at Site 3. Looking upstream from boring 2F-92-23. (April 27, 1992)



Photo 7: Site 4 - Paved highway on top of levee. Looking upstream from boring 2F-92-22. (April 27, 1992)

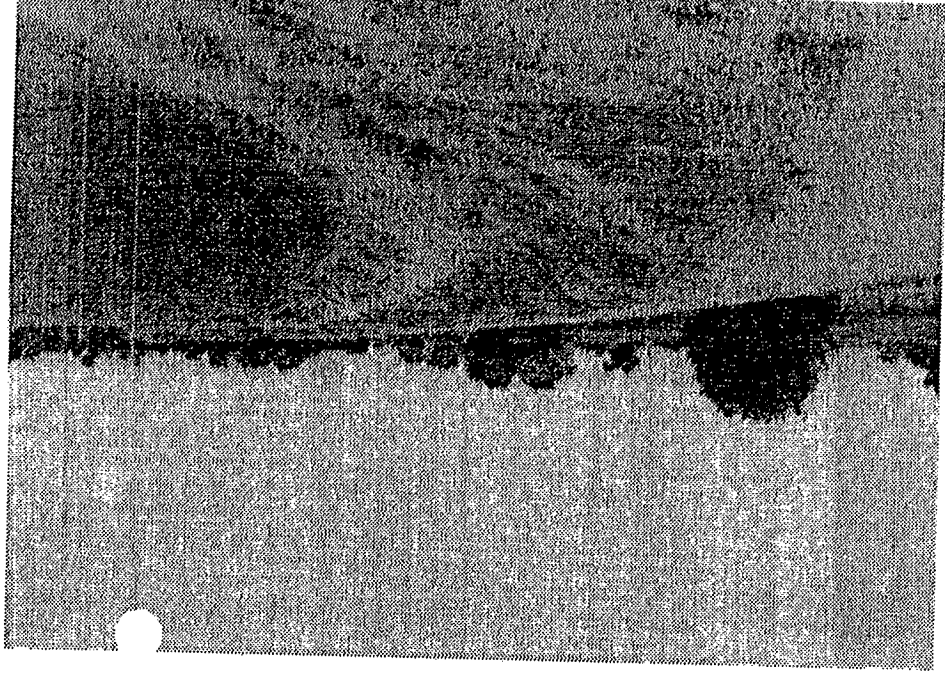


Photo 6: Site 3 - Typical lands ide slope along this site. Looking downstream near boring 2F-92-23. (April 27, 1992)

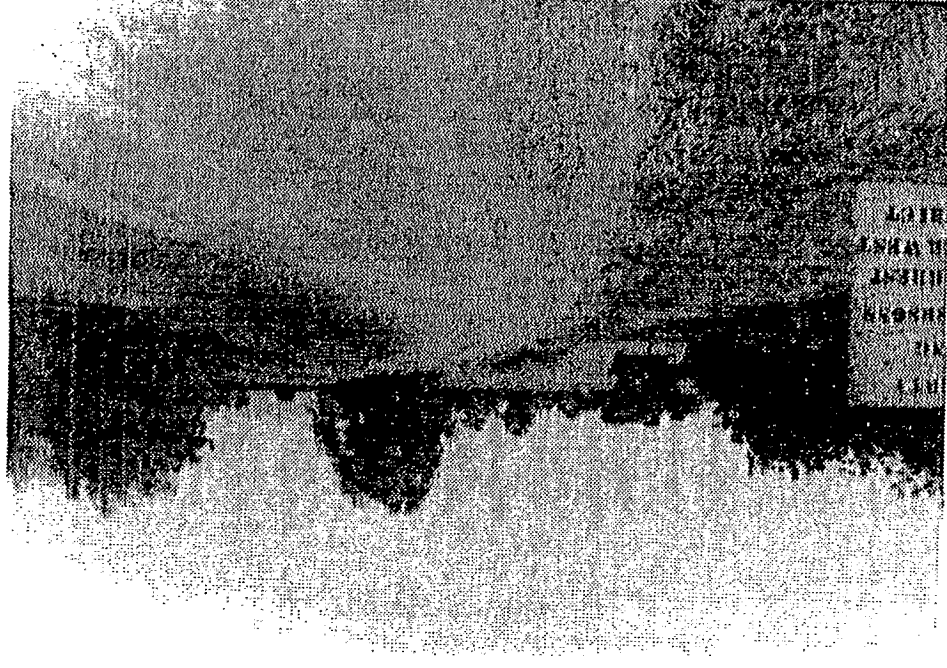


Photo 8: Site 4 - Looking upstream from boring 2F-92-21. (April 27, 1992)

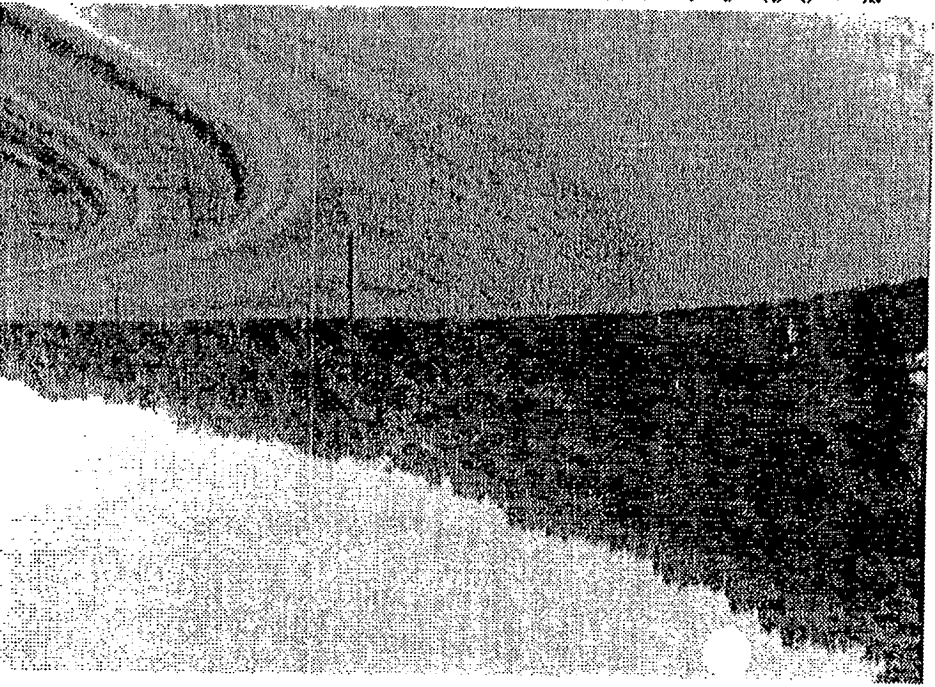


Photo 9: Site 5 - Lands ide slope just downstream of boring 2F-92-19.
(April 27, 1992)



Photo 11: Site 9 - Typical levee along this reach. Looking upstream
from boring 2F-92-18. (April 27, 1992)

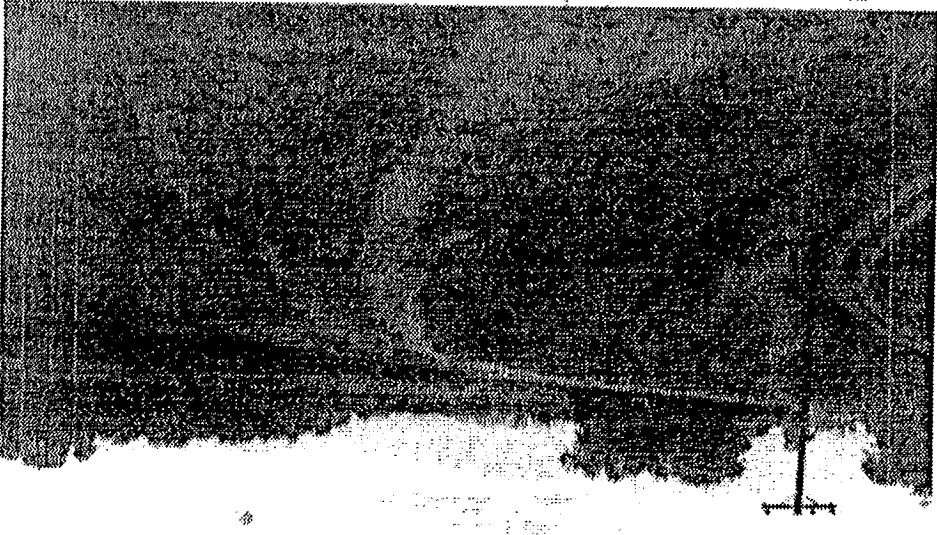


Photo 10: Site 5 - Lands ide slope just upstream of boring 2F-92-19.
(April 27, 1992)



Photo 12: Site 9 - Levee is relatively low along this site. Looking downstream
from boring 2F-92-18. (April 28, 1992)



Photo 13: Site 10 - An irrigation ditch running along the landside toe. Looking downstream near boring 2F-92-14 (Nov 17, 1992)

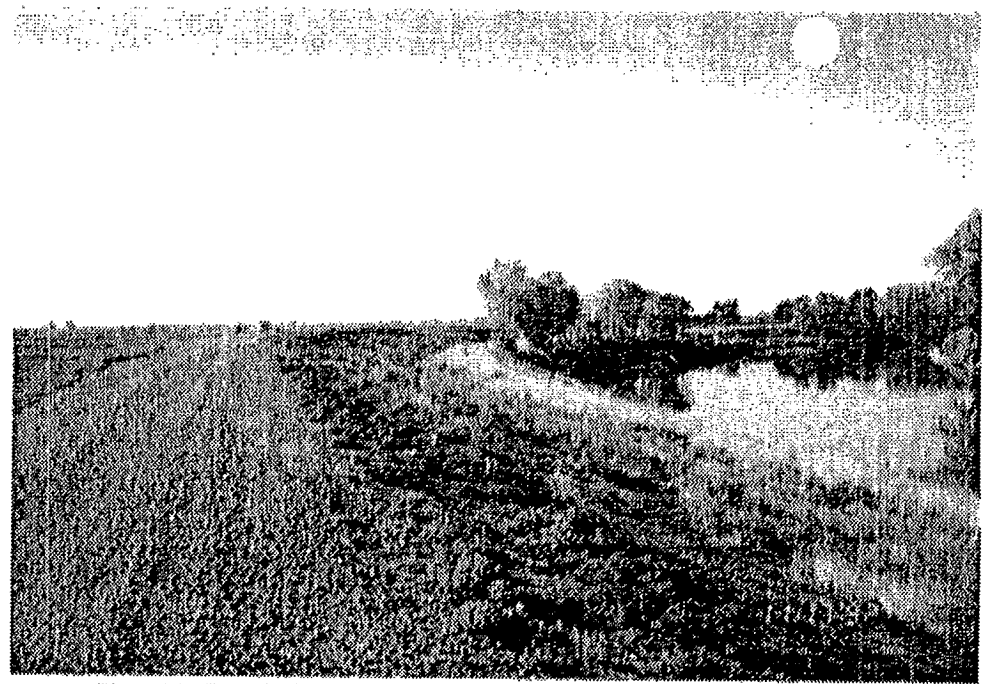


Photo 14: Site 10 - Looking upstream along waterside slope from boring 2F-92-14. (Nov. 17, 1992)



Photo 15: Site 11 - Paved highway on top of levee. Looking downstream along waterside slope near boring 2F-92-11. (Nov 17, 1992)



Photo 16: Site 11 - Looking downstream along landside slope near boring 2F-92-11. (Nov 17, 1992)

Figure 4

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Photo 17: Site 12 - Steep landside slope just upstream of boring 2F-92-9. (Nov 17, 1992)



Photo 18: Site 12 - Looking downstream along landside slope from boring 2F-92-9. (Nov. 17, 1992)

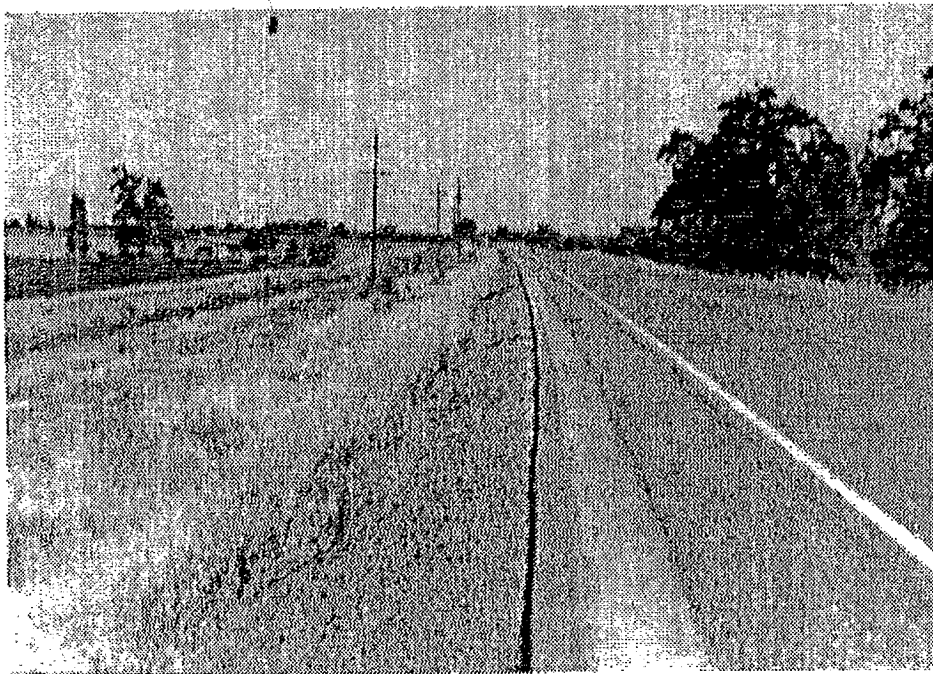


Photo 19: Site 16 - Paved highway on top of levee and an irrigation ditch running parallel to the landside toe throughout this site. (May 21, 1992)



Photo 20: North of Site 16 - 4 inches diameter cast iron pipe through the levee. (May 21, 1992)

Figure 5

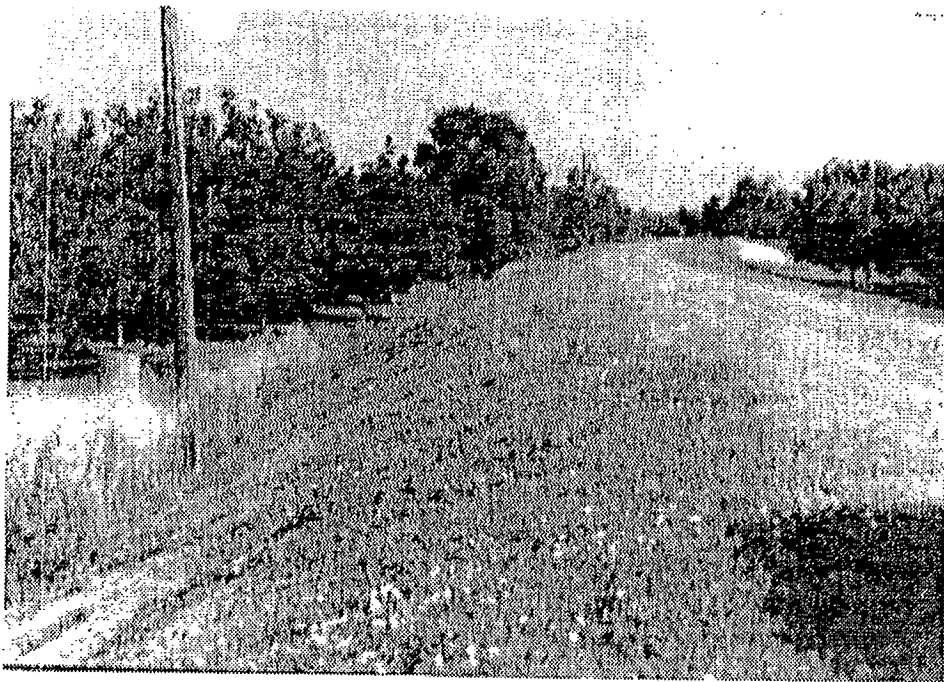


Photo 21: Site 19 - Looking upstream along the lands ide slope from boring 2F-92-1. (May 21, 1992)

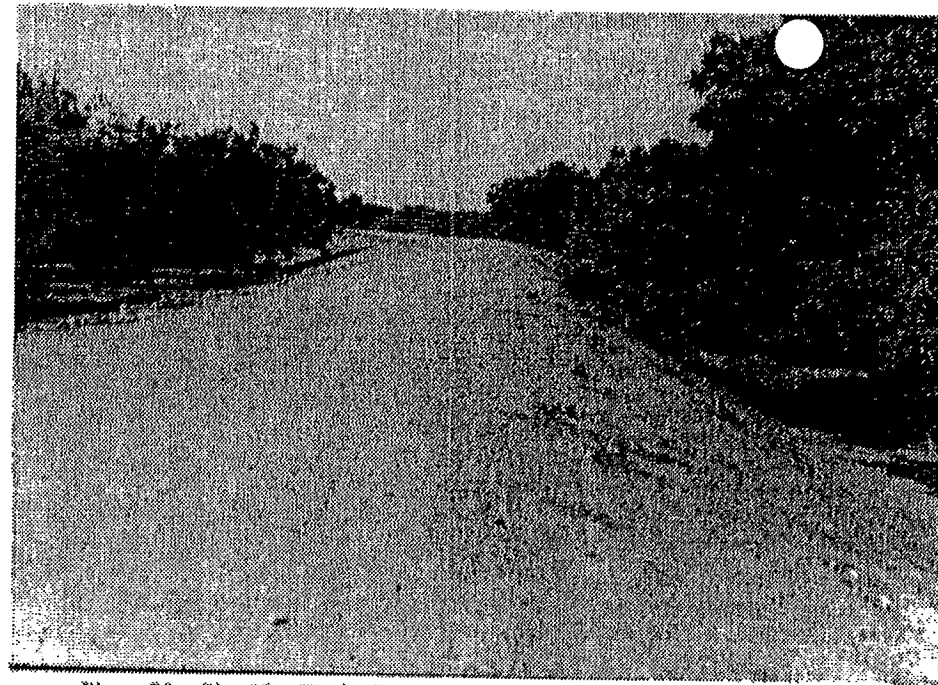


Photo 22: Site 19 - Typical levee along this site. Looking downstream from boring 2F-92-2. (May 21, 1992)

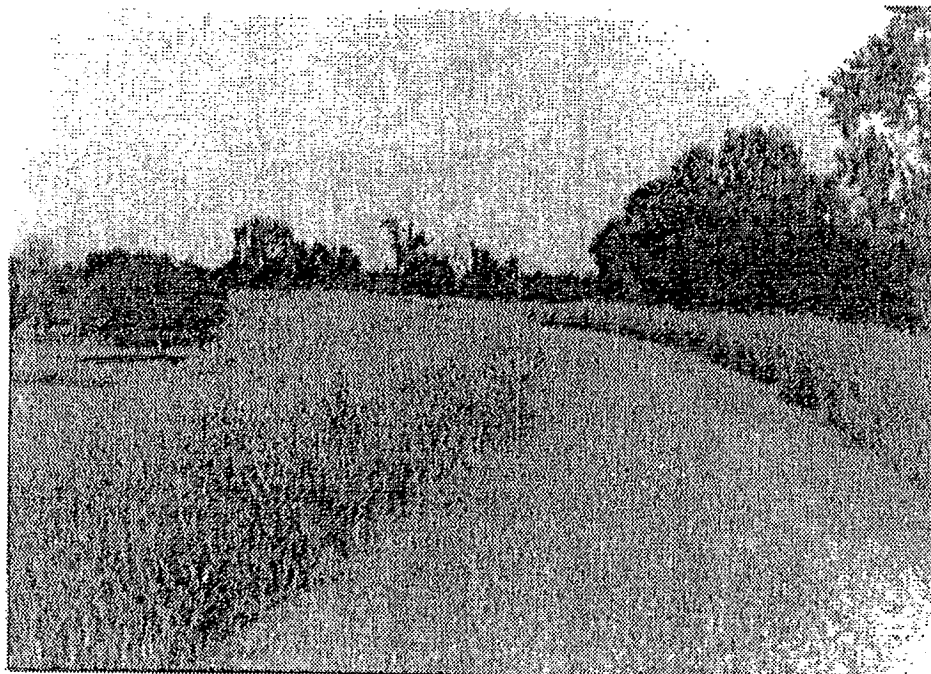


Photo 23: Site 7 - Typical levee along this site. Looking upstream from boring 2F-92-15. (April 28, 1992)

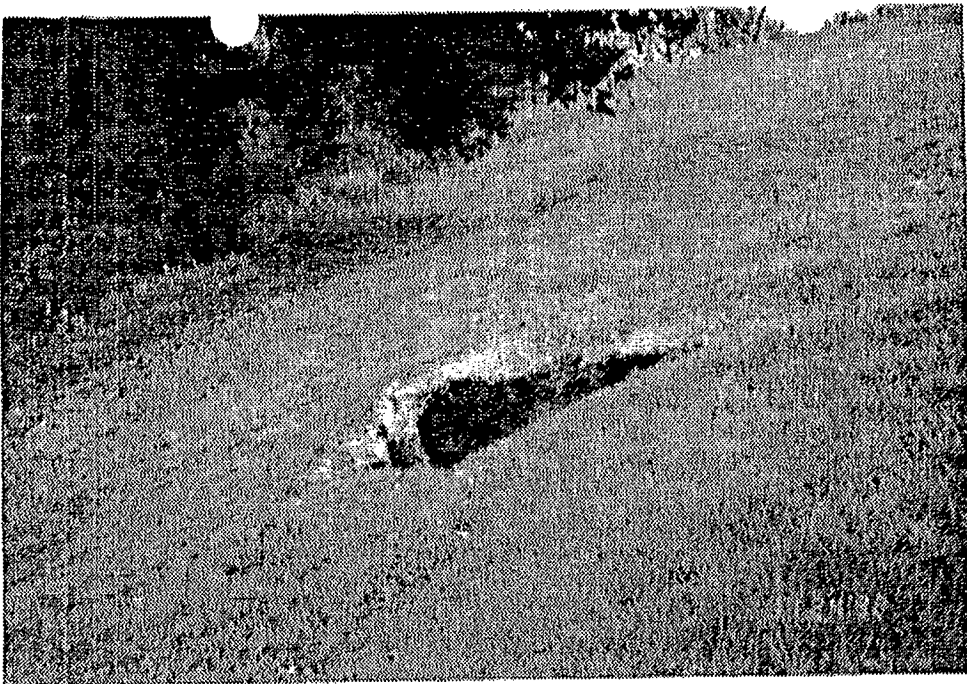


Photo 24: Approx. 1600 ft. north of Site 14 - A very large depression on the riverside slope near levee mile 7.1. (Nov 24, 1992)

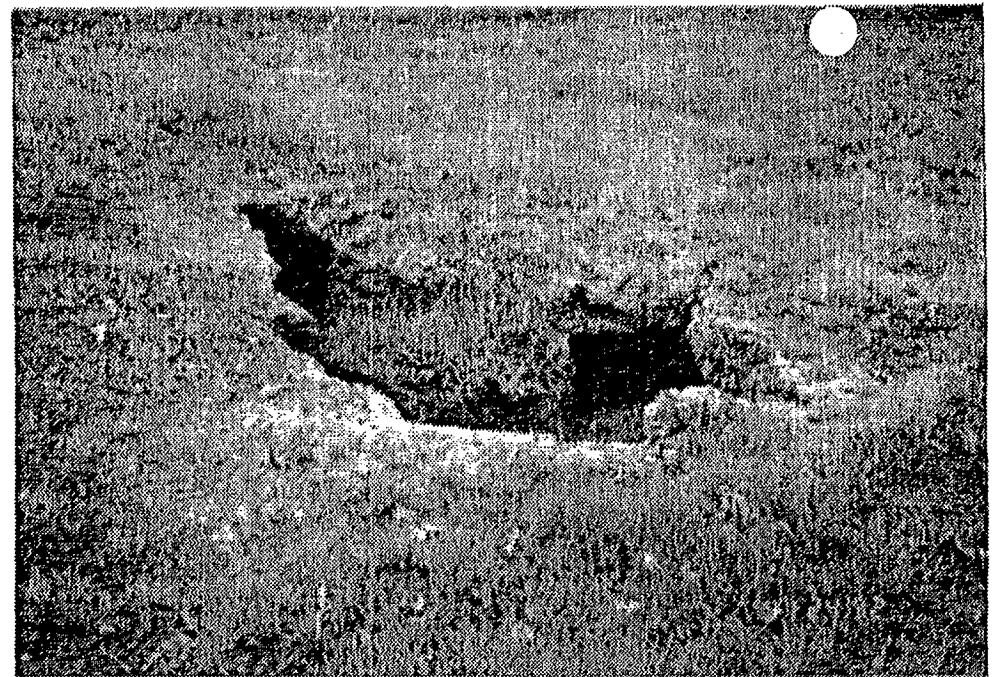


Photo 25: Approx. 1600 ft. north of Site 14 - Different view of the depression. (Nov. 24, 1992)



Photo 26: Site 8 - Looking downstream along lands ide slope. An irrigation ditch running parallel to the lands ide toe. (May 21, 1992)

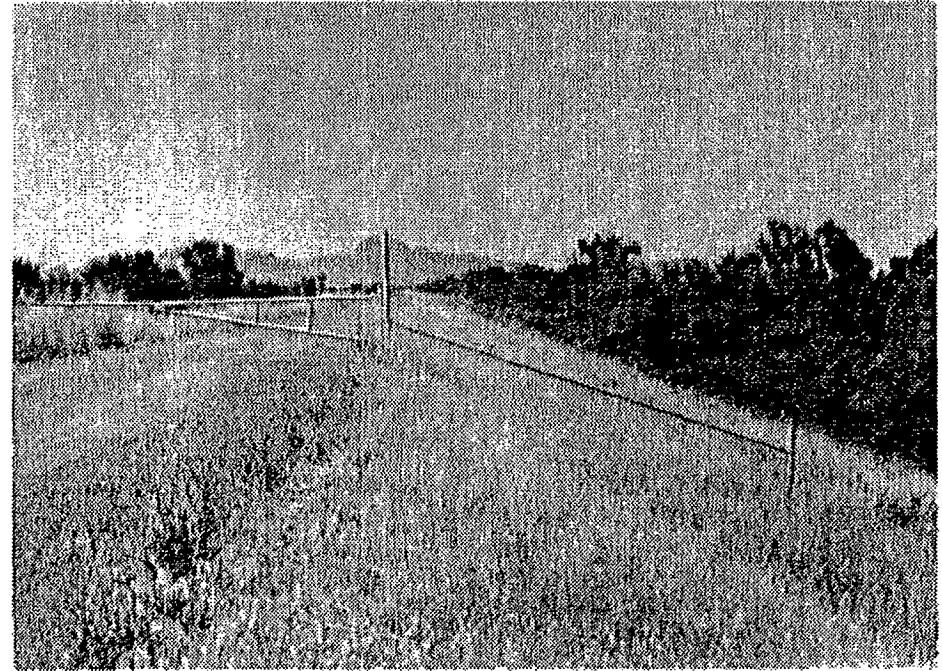


Photo 27: Site 8 - Looking upstream along waterside slope. (May 21, 1992)

Figure 7

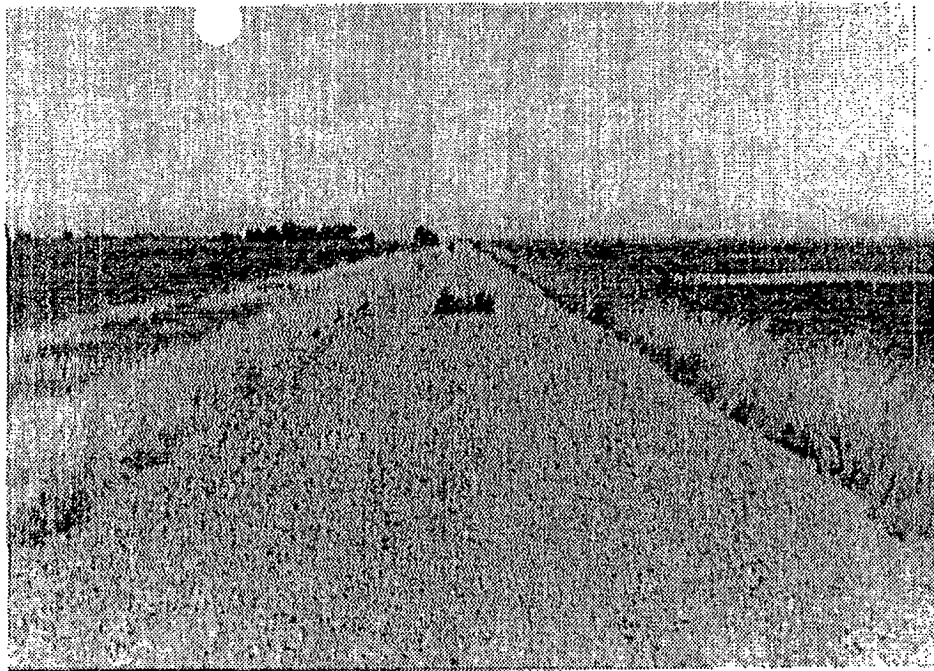


Photo 28: Site 20 - Cherokee Canal. Typical South bank levee .
(May 21, 1992)

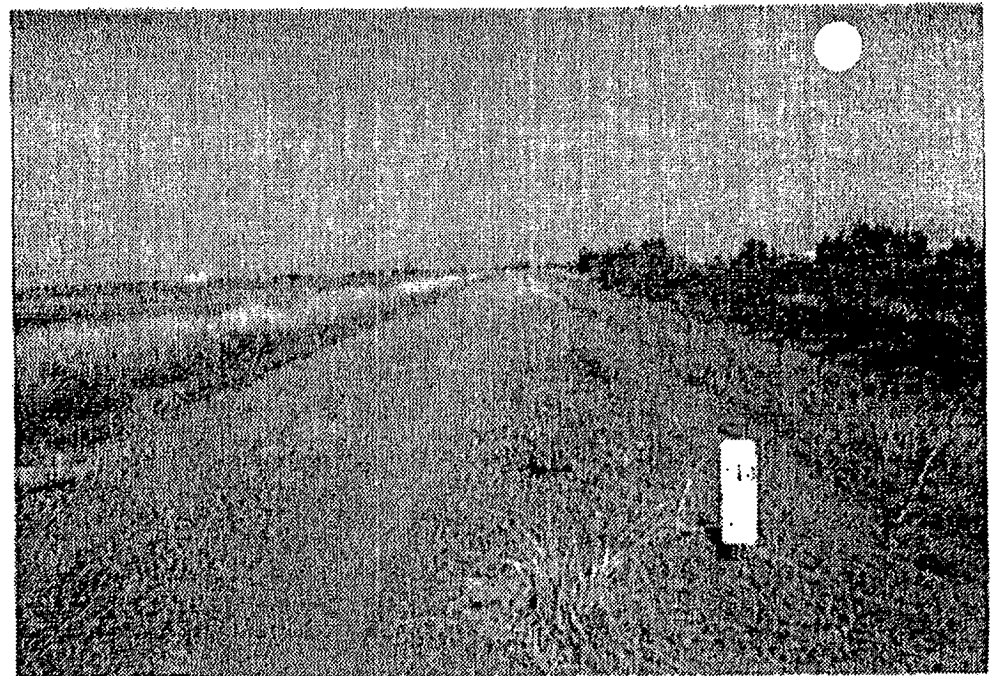


Photo 29: Cherokee Canal - Typical North bank levee
(Oct 27 1992)

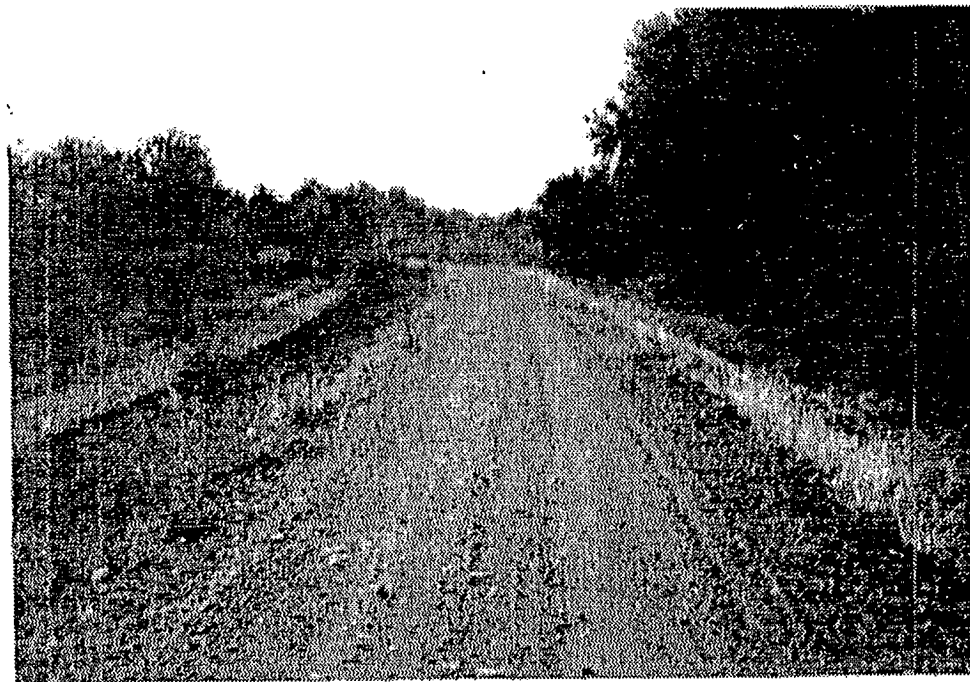


Photo 30: Typical levee at Butte Creek. Looking downstream along
North bank levee. (Oct 27, 1992)



Photo 31: Typical levee at Mud Creek. Looking upstream along
South bank levee. (Oct 27, 1992)

Figure 8

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C-103891



Photo 32: Typical levee at Sycamore Creek. Looking upstream along North bank levee. (Oct 26, 1992)



Photo 33: Typical levee of Deer Creek. Looking downstream along South bank levee. (Oct 26, 1992)



Photo 34: Elder Creek. Typical South bank levee. (Oct 26, 1992)



Photo 35: Elder Creek - Typical North bank levee (Oct 27 1992)

Figure 9

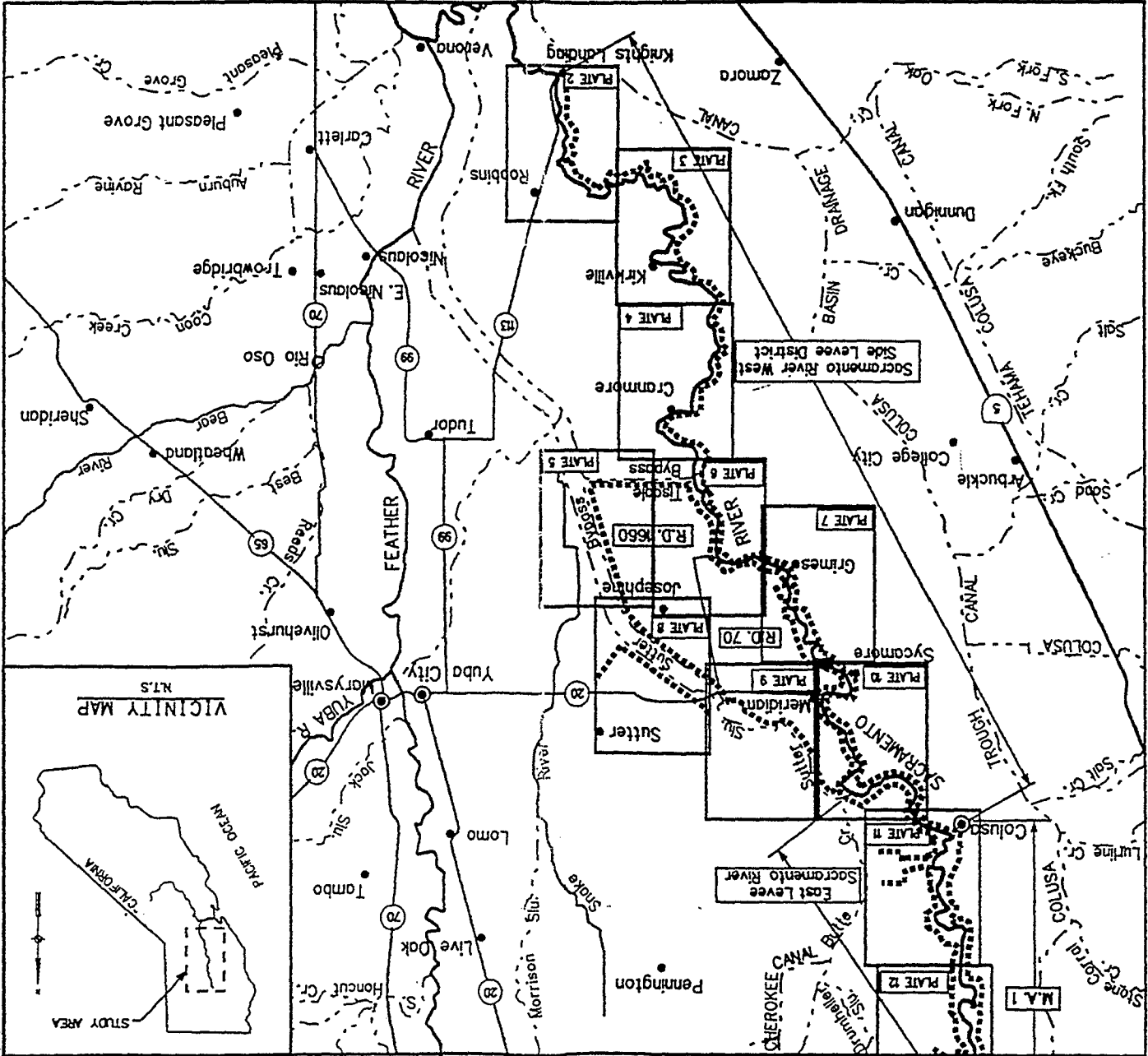
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2

**BASIS OF DESIGN
GEOTECHNICAL EVALUATION OF LEVEES
FOR
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION
UPPER SACRAMENTO AREA - PHASE V**

PLATES

MATCH LINE

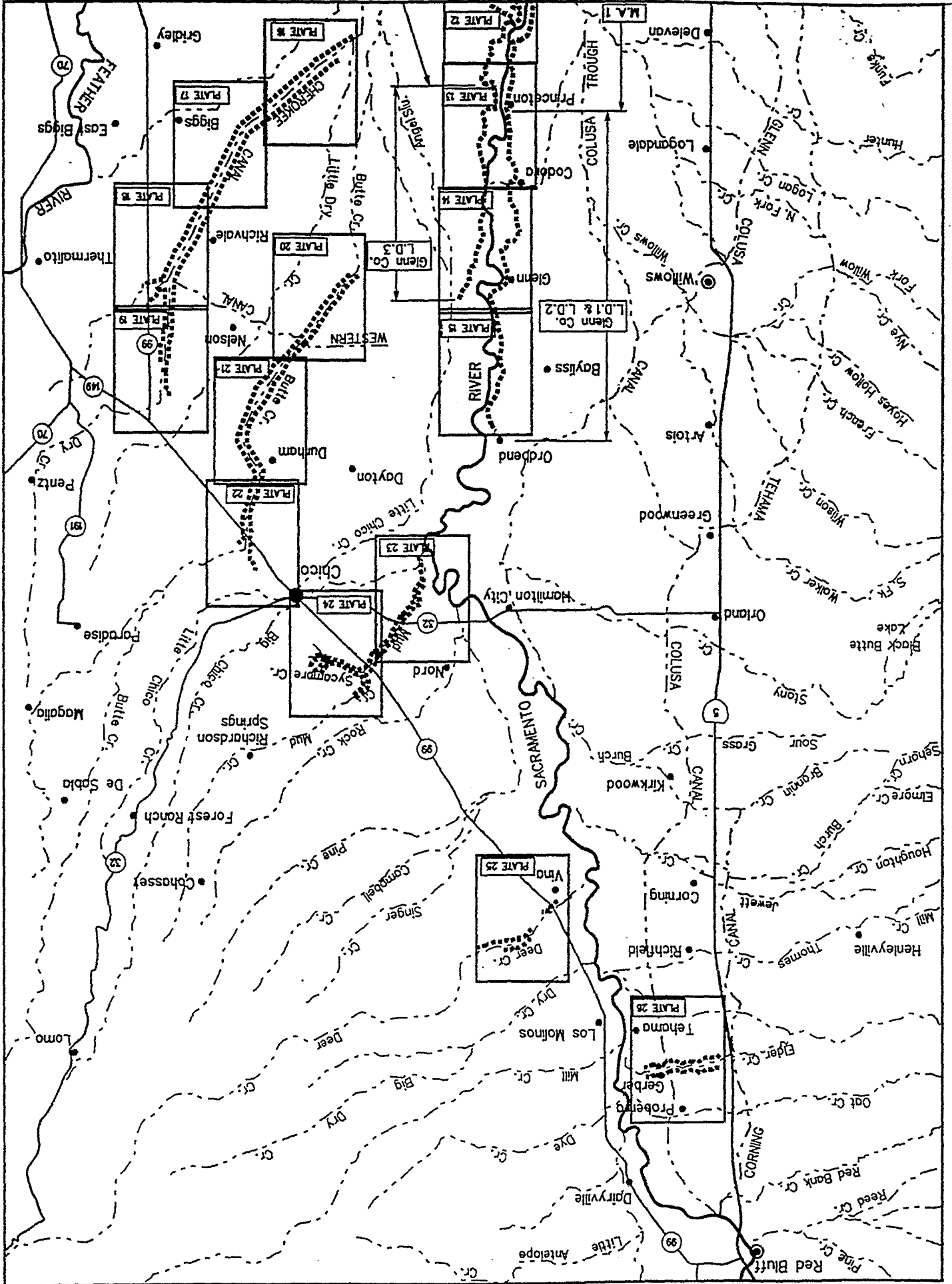


LEGEND (For PLATES 2 - 26)

- Seepage around pipe thru levee
- Seepage in ditch dug perpendicular
- Past sink hole site
- Location of Exploration
- Location of Past Exploration
- Approx. location and direction of photo

DEPARTMENT OF THE ARMY	
SACRAMENTO DISTRICT CORPS OF ENGINEERS	
SACRAMENTO, CALIFORNIA	
SOIL DESIGN SECTION	
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION	
UPPER SACRAMENTO AREA - PHASE V	
INDEX MAP	
AS SHOWN Nov. 20, 1962	
SACRAMENTO, CALIF.	

MATCH LINE



GRAPHIC SCALES

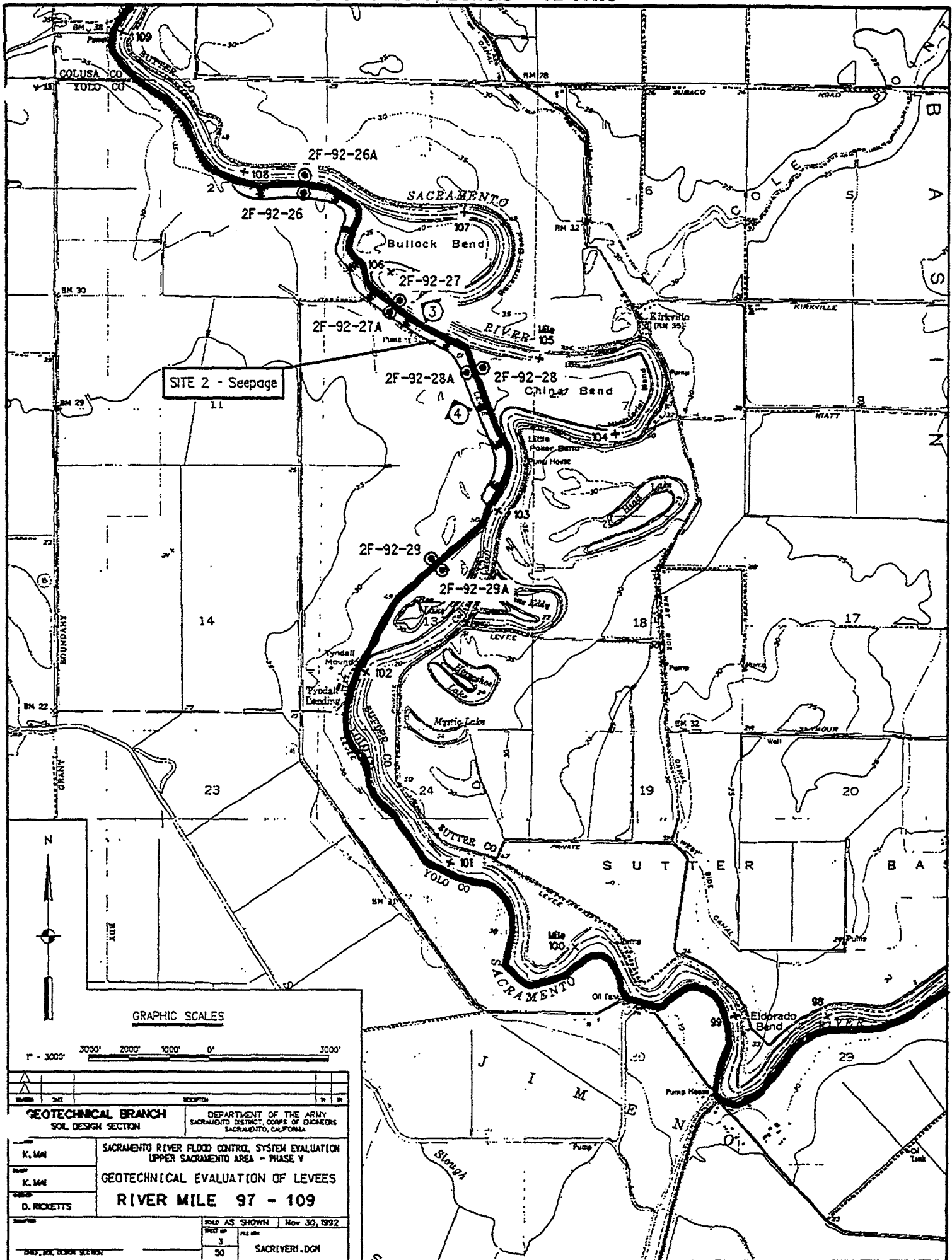
1" = 3000'

3000' 2000' 1000' 0' 3000'

SYMBOL	SIZE	DESCRIPTION	REF. NO.
△			
△			

GEOTECHNICAL BRANCH		DEPARTMENT OF THE ARMY	
SOIL DESIGN SECTION		SACRAMENTO DISTRICT, CORPS OF ENGINEERS	
K. M. M.		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION	
K. M. M.		UPPER SACRAMENTO AREA - PHASE V	
D. RICKETTS		GEOTECHNICAL EVALUATION OF LEVEES	
		RIVER MILE 90 - 97	
DATE		SCALE AS SHOWN	REV. NO.
04/7, 04/8, 04/9		2	Nov 30, 1992
		50	SACRIVER1.DGN

PLATE 2



GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
K. MAI K. MAI D. RICKETTS		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES RIVER MILE 97 - 109	
DRAWN BY: SACRIYER.DGN DATE: Nov 30, 1992		CHECKED BY: 50	

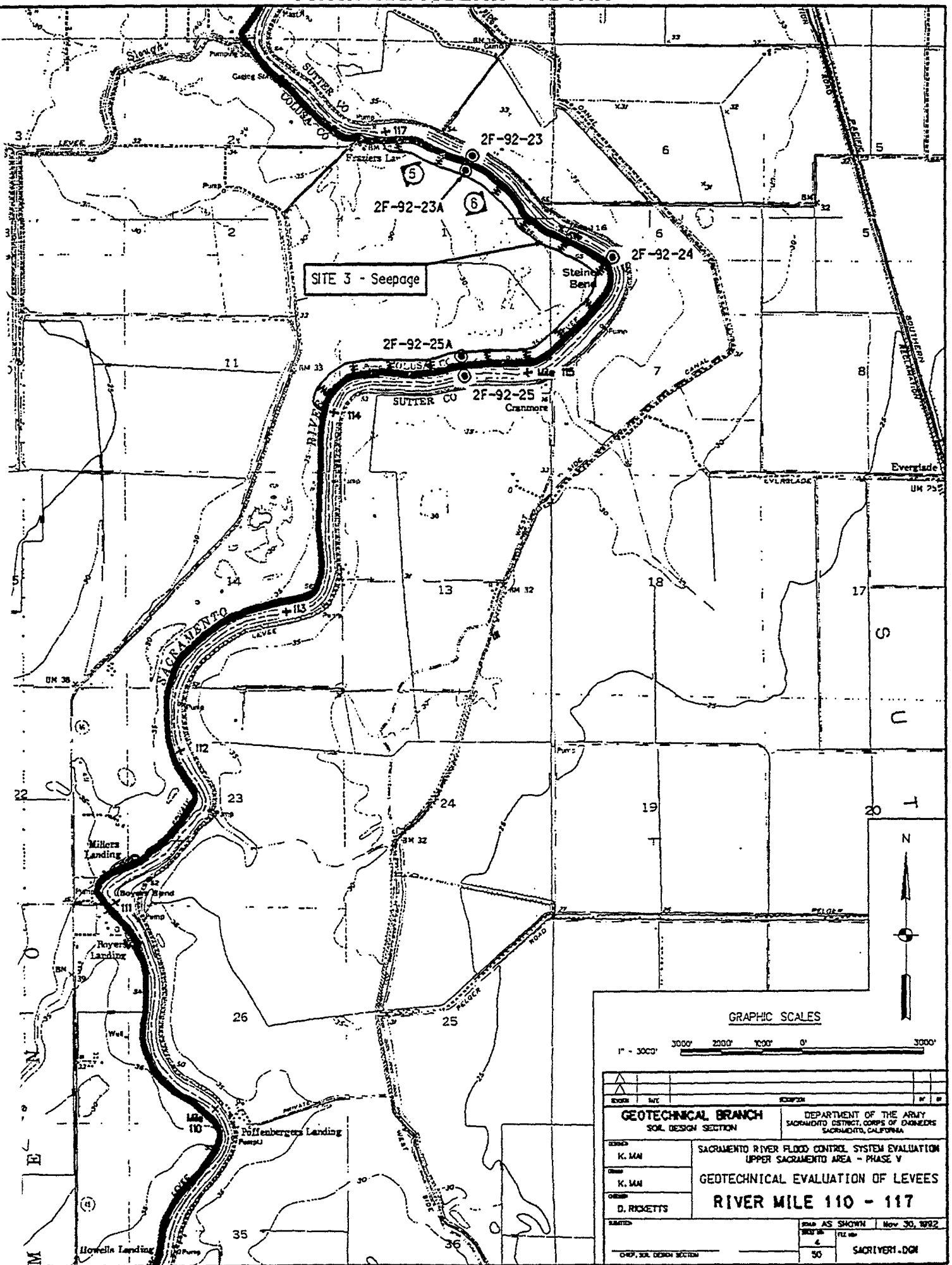
SAFETY PAYS

PLATE 3

C - 1 0 3 8 9 6

C-103896

FUNCTIONAL ANALYSIS - VE PAYS



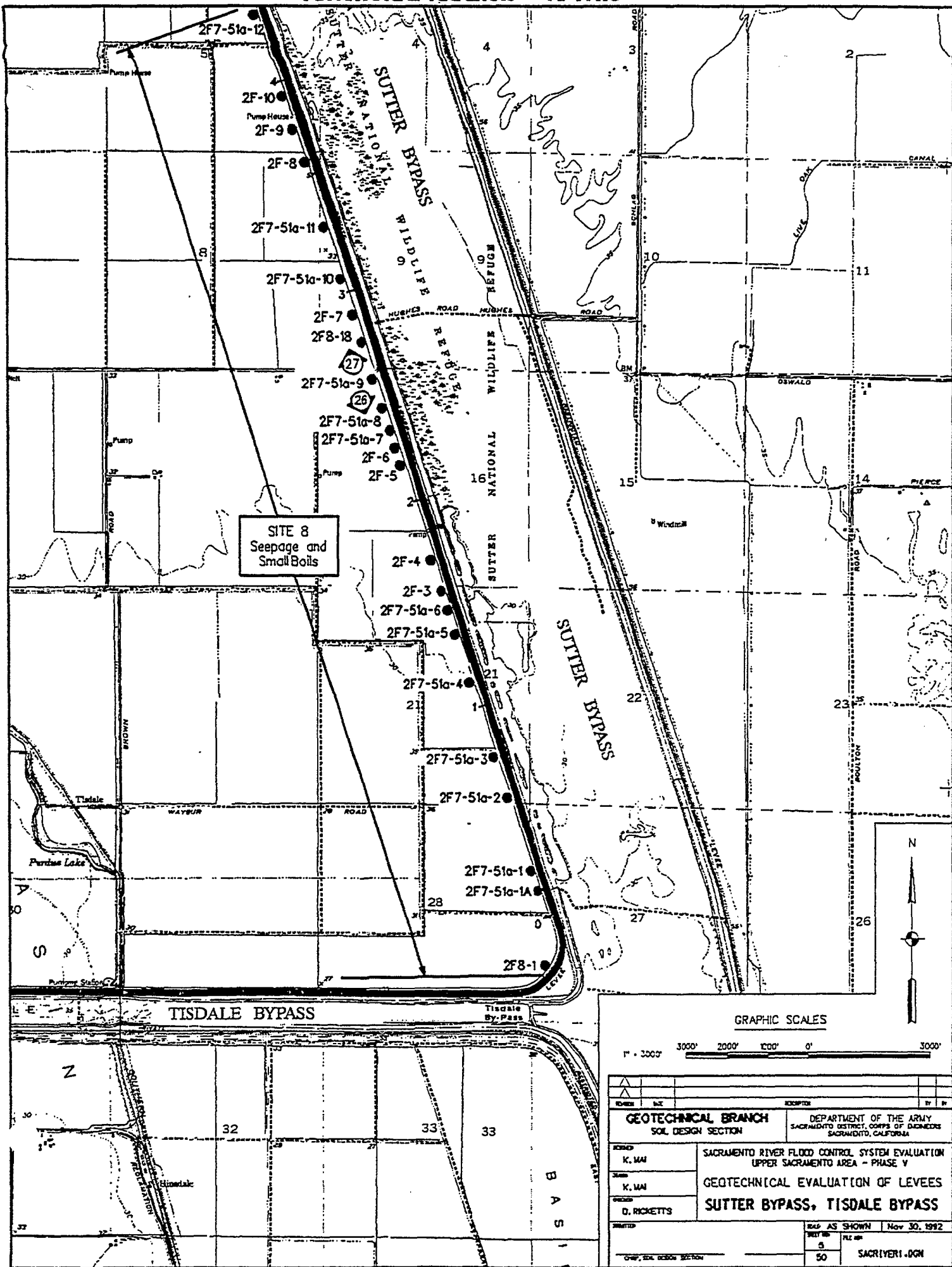
SAFETY PAYS

PLATE 4

C - 1 0 3 8 9 7

C-103897

FUNCTIONAL ANALYSIS - VE PAYS



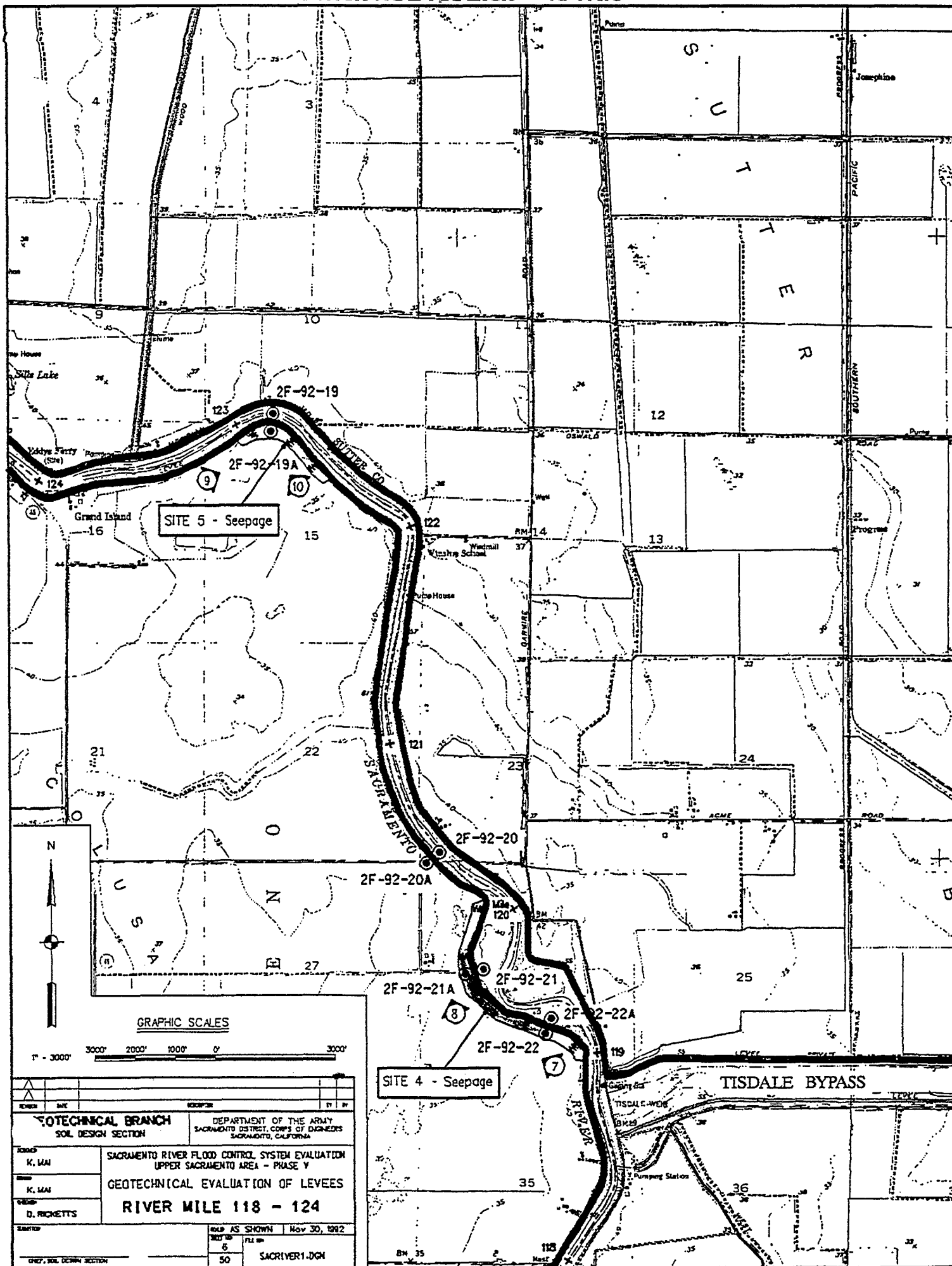
SAFETY PAYS

PLATE 5

C - 1 0 3 8 9 8

C-103898

FUNCTIONAL ANALYSIS - VE PAYS



GRAPHIC SCALES

1" = 3000'

GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
CHECKED K. MAI	GEOTECHNICAL EVALUATION OF LEVEES		
DRAWN D. RICKETTS	RIVER MILE 118 - 124		
DATE Nov 30, 1992	SCALE AS SHOWN	FILE NO. 50	PROJECT SACRIVER1.DGN
SHEET NO. 50			

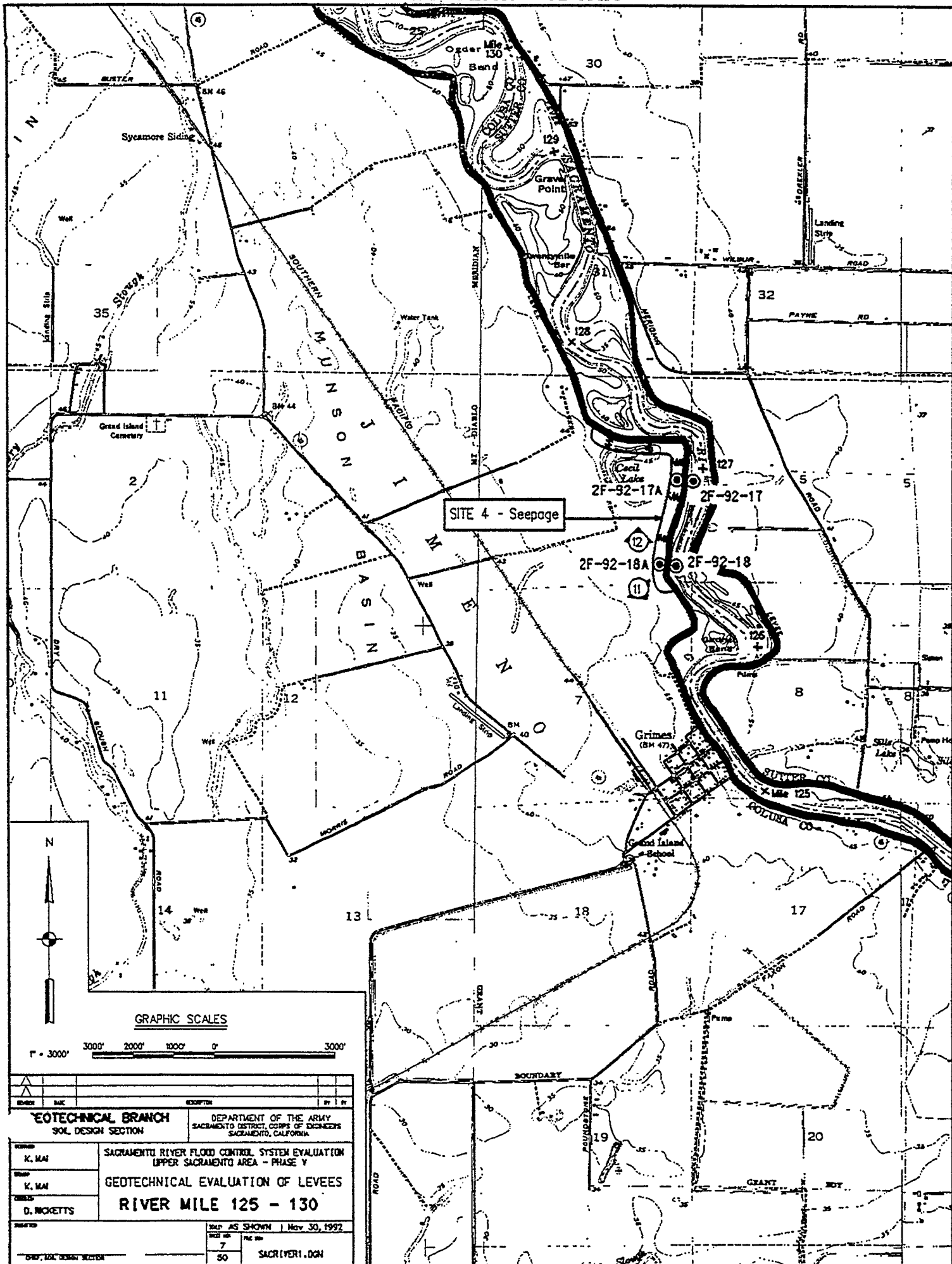
SAFETY PAYS

PLATE 6

C-103899

C-103899

FUNCTIONAL ANALYSIS - VE PAYS

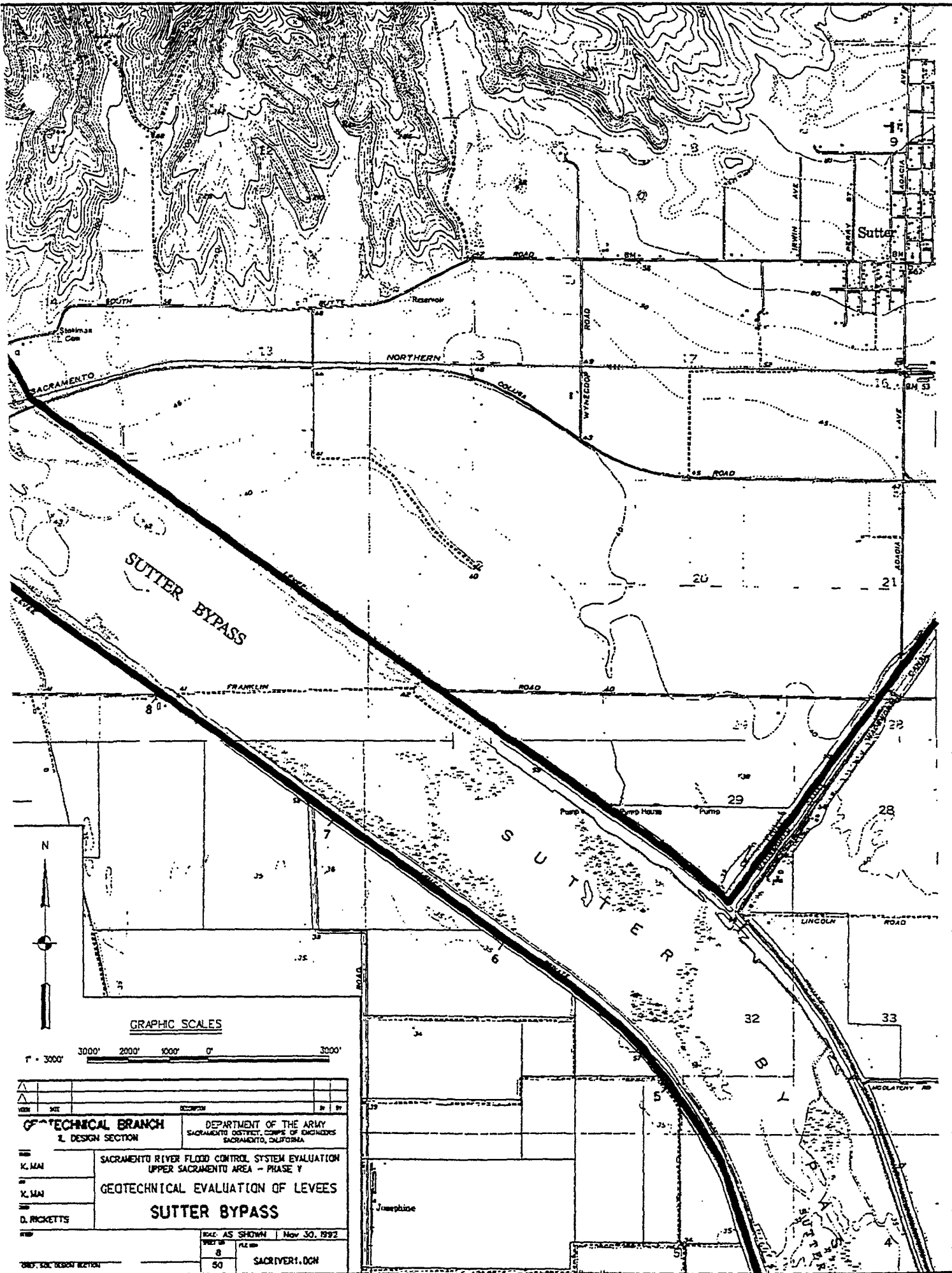


SAFETY PAYS

PLATE 7

C-103900

C-103900



GEOTECHNICAL BRANCH 2. DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
K. MAI K. MAI D. RICKETTS	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE Y GEOTECHNICAL EVALUATION OF LEVEES SUTTER BYPASS		
SCALE: AS SHOWN Nov 30, 1992		FILE NO. SACRIVER1.DGN	

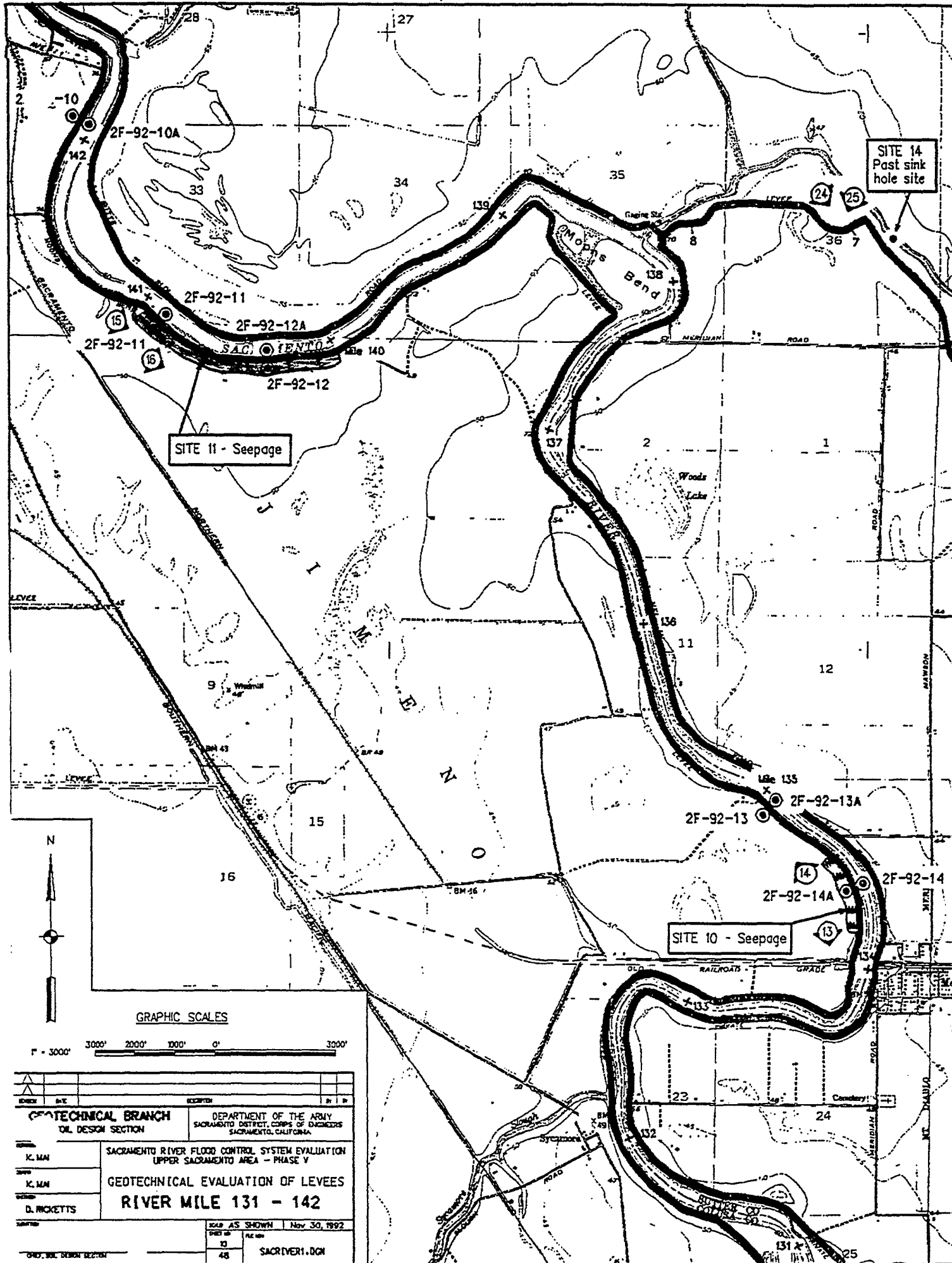
SAFETY PAYS

PLATE 8

C - 1 0 3 9 0 1

C-103901



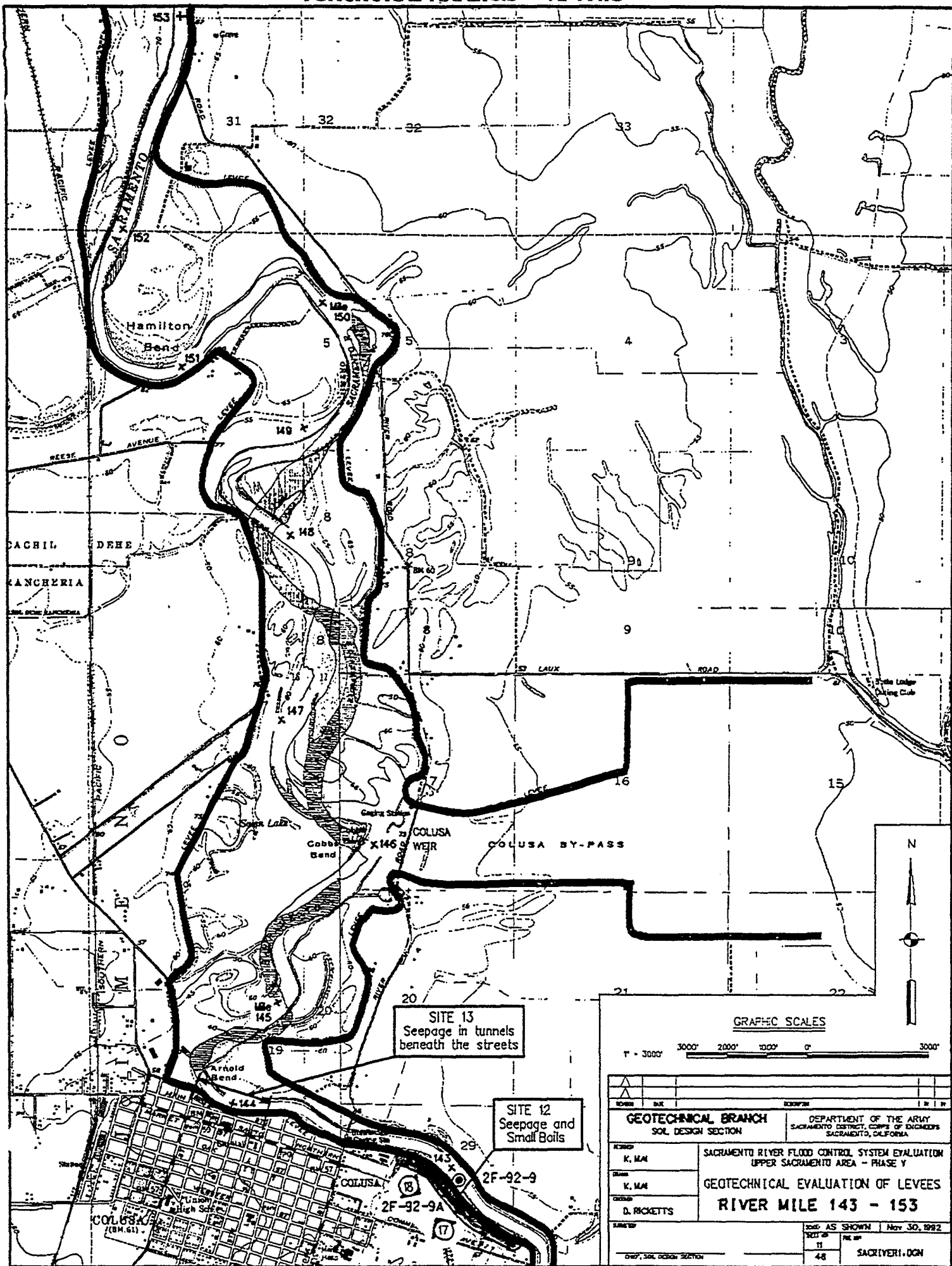


SAFETY PAYS

PLATE 10

C-103903

C-103903



SITE 13
Seepage in tunnels
beneath the streets

SITE 12
Seepage and
Small Bails

GRAPHIC SCALES

1" = 3000'

3000'	2000'	1000'	0'	3000'
-------	-------	-------	----	-------

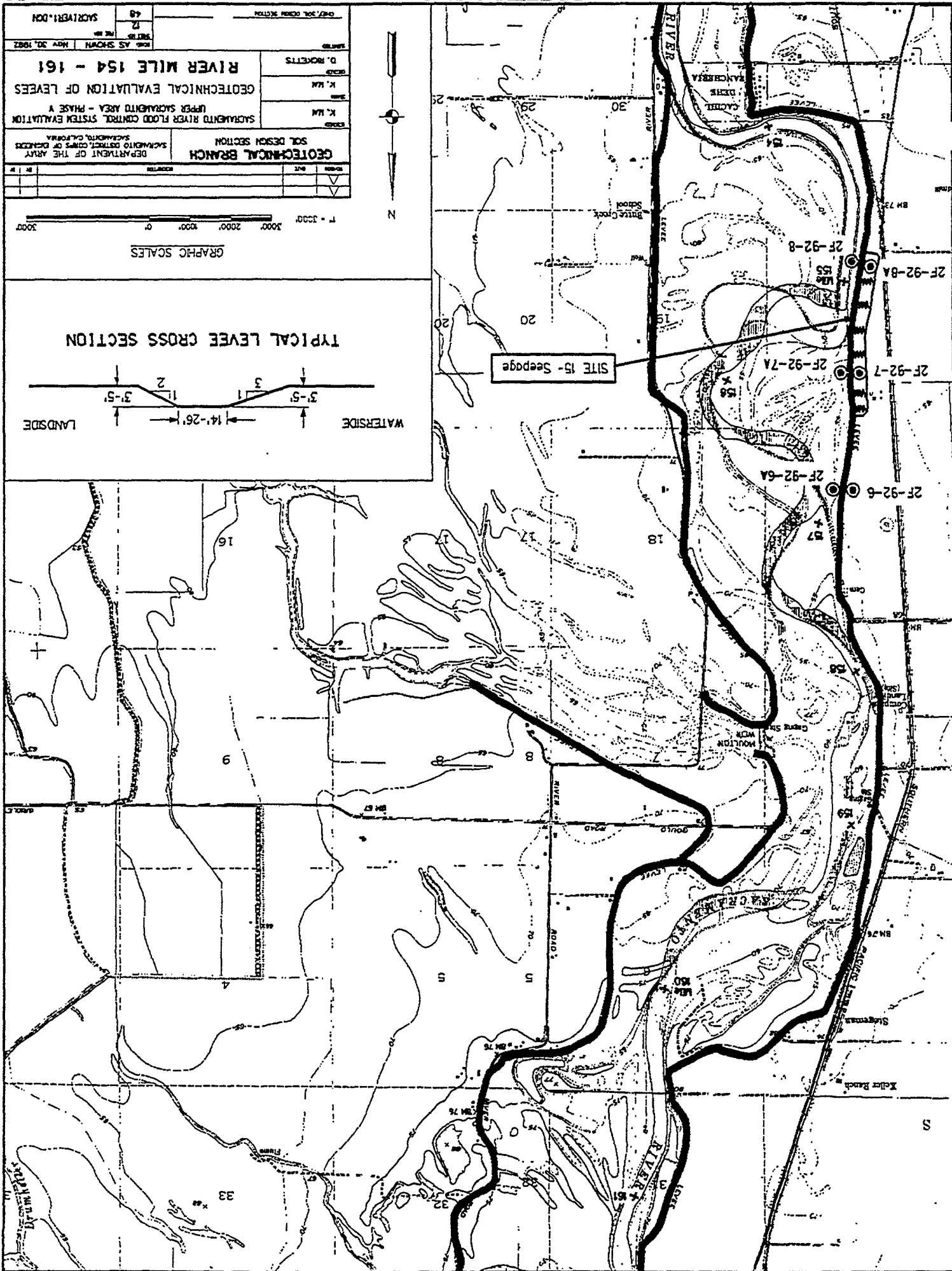
GEOTECHNICAL BRANCH	DEPARTMENT OF THE ARMY
SOL DESIGN SECTION	SACRAMENTO DISTRICT, CORPS OF ENGINEERS
	SACRAMENTO, CALIFORNIA

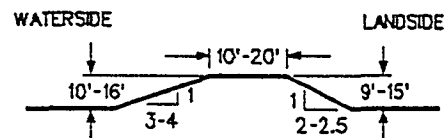
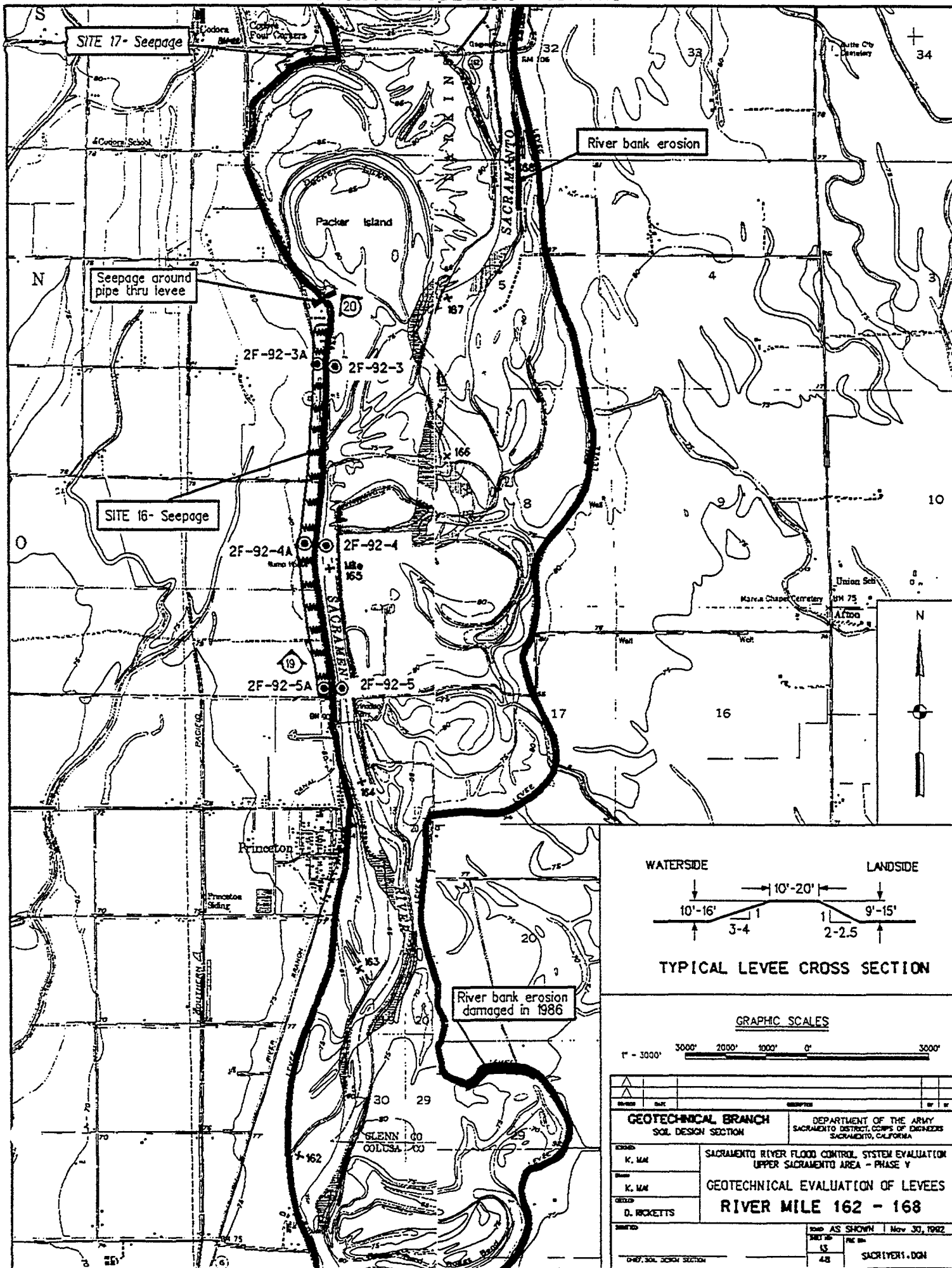
PROJECT K, MA	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V
DESIGN K, MA	GEOTECHNICAL EVALUATION OF LEVEES
CHECKED D. RICKETTS	RIVER MILE 143 - 153

DATE Nov 30, 1992	SCALE AS SHOWN
11	48
NOV 30, 1992	SACRIVER1.DGN

SAFETY PAYS

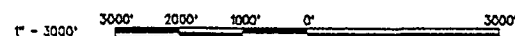
PLATE 11





TYPICAL LEVEE CROSS SECTION

GRAPHIC SCALES



GEOTECHNICAL BRANCH
SOIL DESIGN SECTION

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED BY
K. MAI
CHECKED BY
K. MAI
DRAWN BY
D. RICKETTS

SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION
UPPER SACRAMENTO AREA - PHASE V

GEOTECHNICAL EVALUATION OF LEVEES
RIVER MILE 162 - 168

DATE

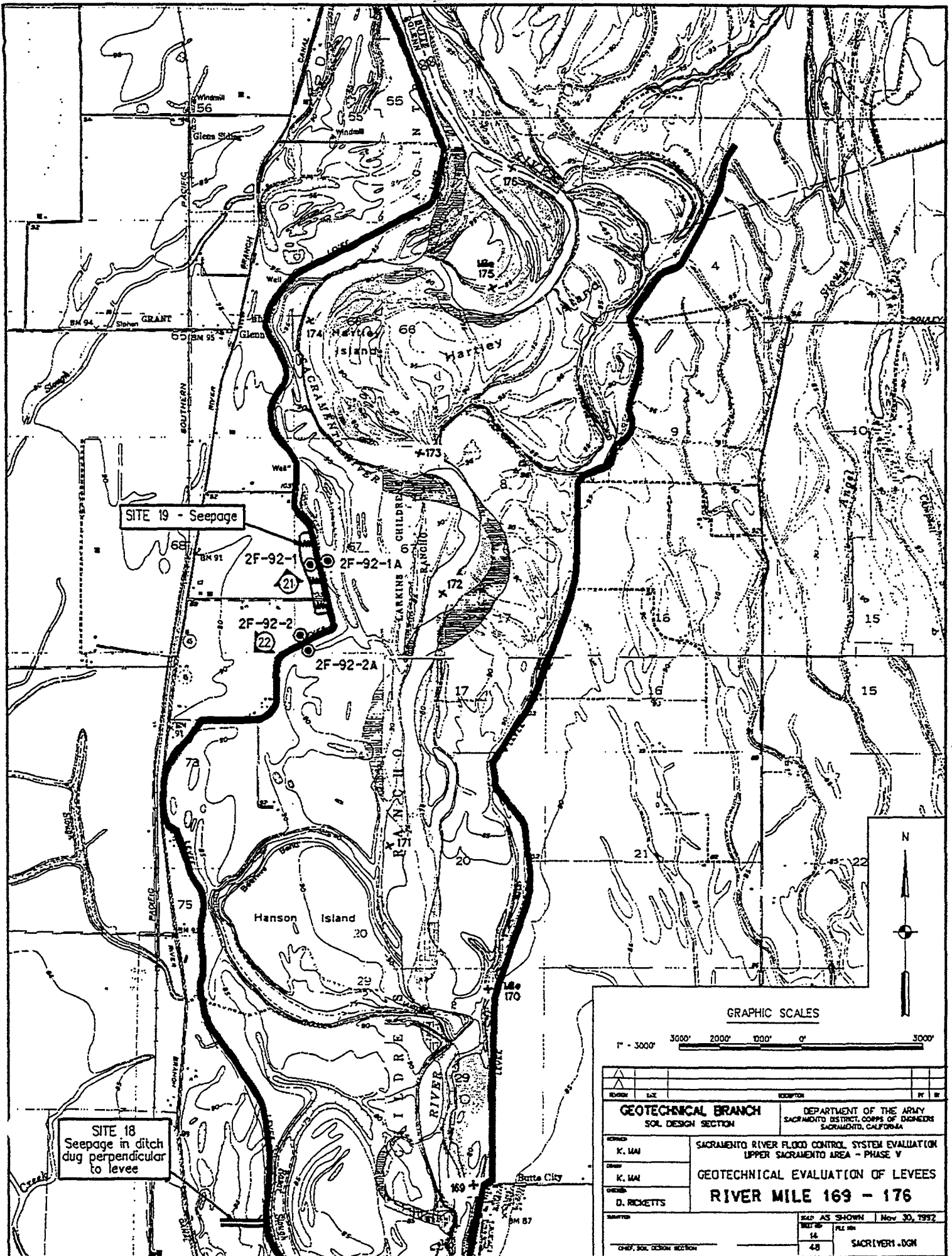
1000 AS SHOWN Nov 30, 1992

NO. 13

FILE NO.

42

SACRIY1.DGN



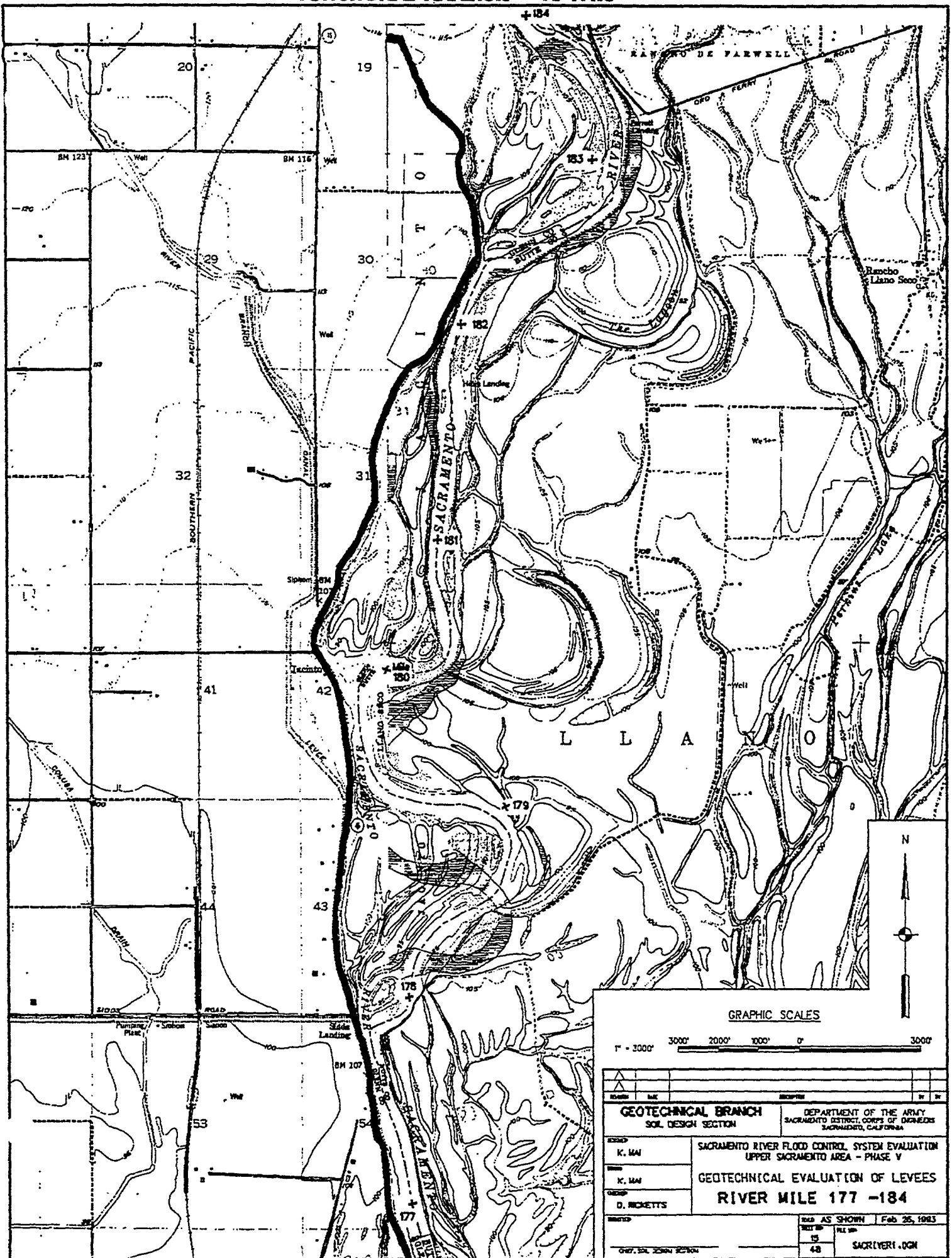
SAFETY PAYS

PLATE 14

C - 1 0 3 9 0 7

C-103907

FUNCTIONAL ANALYSIS - VE PAYS



GRAPHIC SCALES																															
1" = 3000'	3000' 2000' 1000' 0' 3000'																														
<table border="1"> <tr> <th>NO.</th> <th>DATE</th> <th>DESCRIPTION</th> <th>BY</th> <th>CHK</th> </tr> <tr> <td colspan="5"> GEOTECHNICAL BRANCH SOIL DESIGN SECTION </td> </tr> <tr> <td colspan="2"> DESIGNED K. MAI </td> <td colspan="3"> DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA </td> </tr> <tr> <td colspan="2"> DRAWN K. MAI </td> <td colspan="3"> SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V </td> </tr> <tr> <td colspan="2"> CHECKED D. RICKETTS </td> <td colspan="3"> GEOTECHNICAL EVALUATION OF LEVEES RIVER MILE 177 - 184 </td> </tr> <tr> <td colspan="2"> DATE FEB 26, 1963 </td> <td colspan="3"> FILE NO. SACR1YR1.DGN </td> </tr> </table>		NO.	DATE	DESCRIPTION	BY	CHK	GEOTECHNICAL BRANCH SOIL DESIGN SECTION					DESIGNED K. MAI		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA			DRAWN K. MAI		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V			CHECKED D. RICKETTS		GEOTECHNICAL EVALUATION OF LEVEES RIVER MILE 177 - 184			DATE FEB 26, 1963		FILE NO. SACR1YR1.DGN		
NO.	DATE	DESCRIPTION	BY	CHK																											
GEOTECHNICAL BRANCH SOIL DESIGN SECTION																															
DESIGNED K. MAI		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA																													
DRAWN K. MAI		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V																													
CHECKED D. RICKETTS		GEOTECHNICAL EVALUATION OF LEVEES RIVER MILE 177 - 184																													
DATE FEB 26, 1963		FILE NO. SACR1YR1.DGN																													

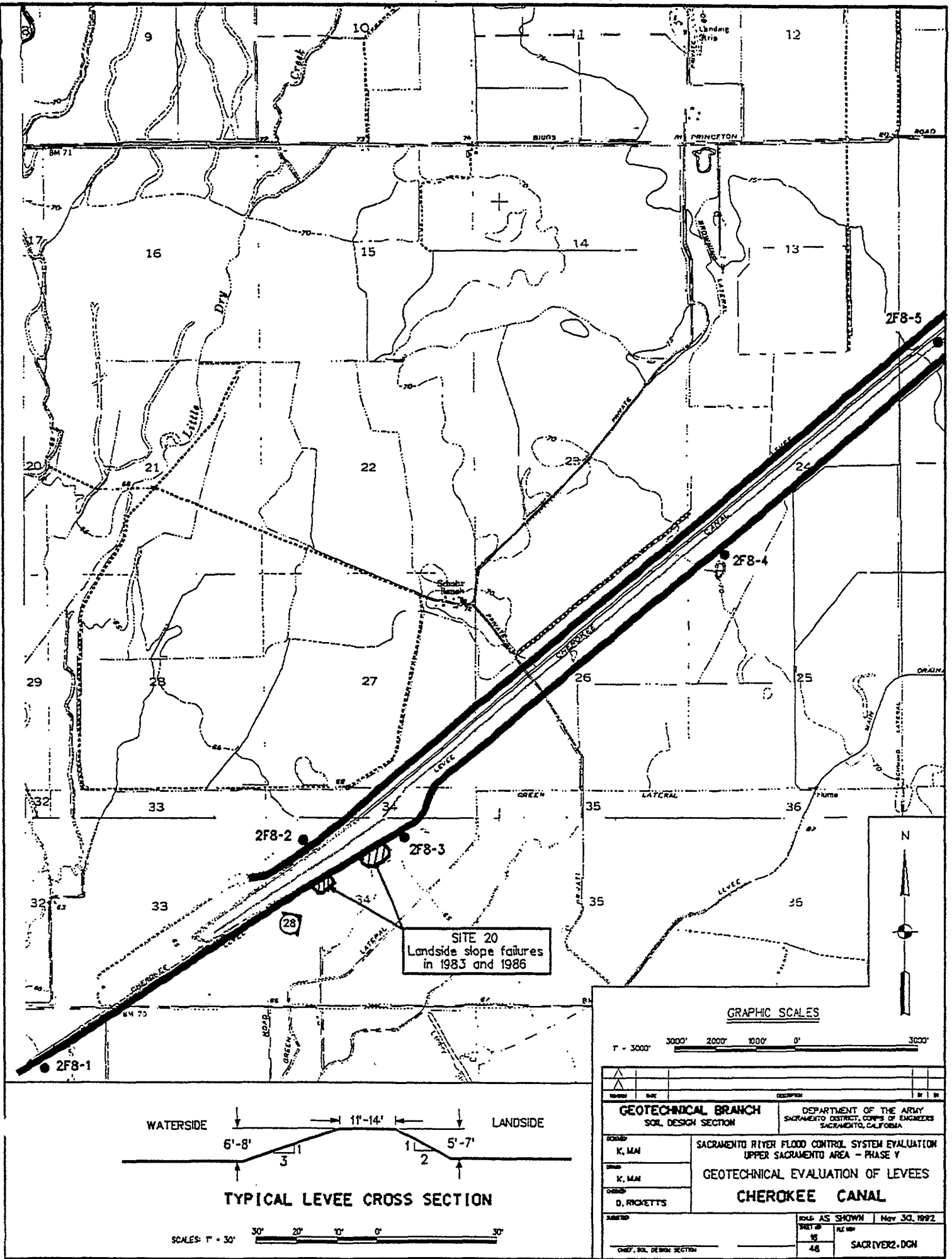
SAFETY PAYS

PLATE 15

C - 1 0 3 9 0 8

C-103908

FUNCTIONAL ANALYSIS - VE PAYS



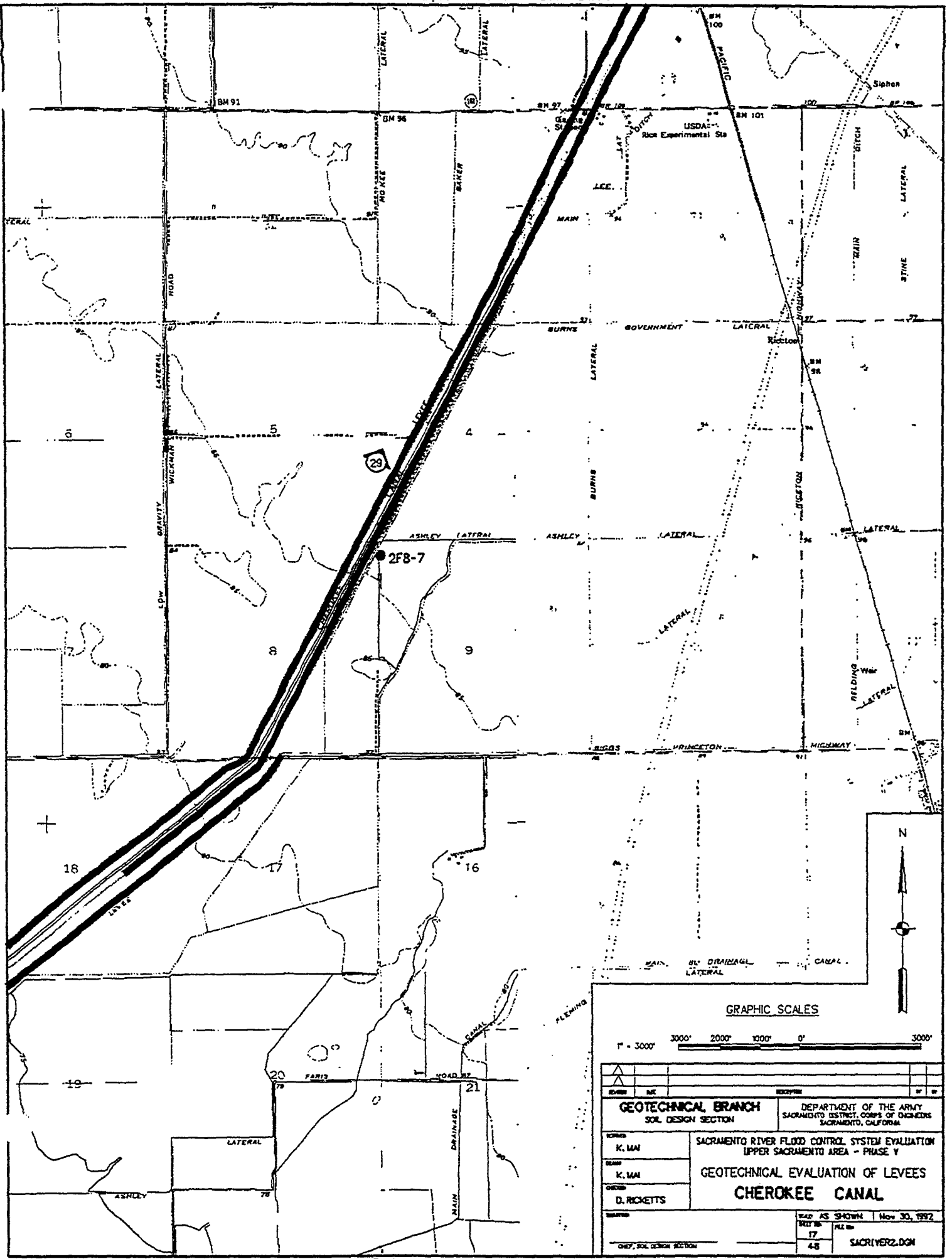
SAFETY PAYS

PLATE 16

C-103909

C-103909

FUNCTIONAL ANALYSIS - VE PAYS



SAFETY PAYS

PLATE 17

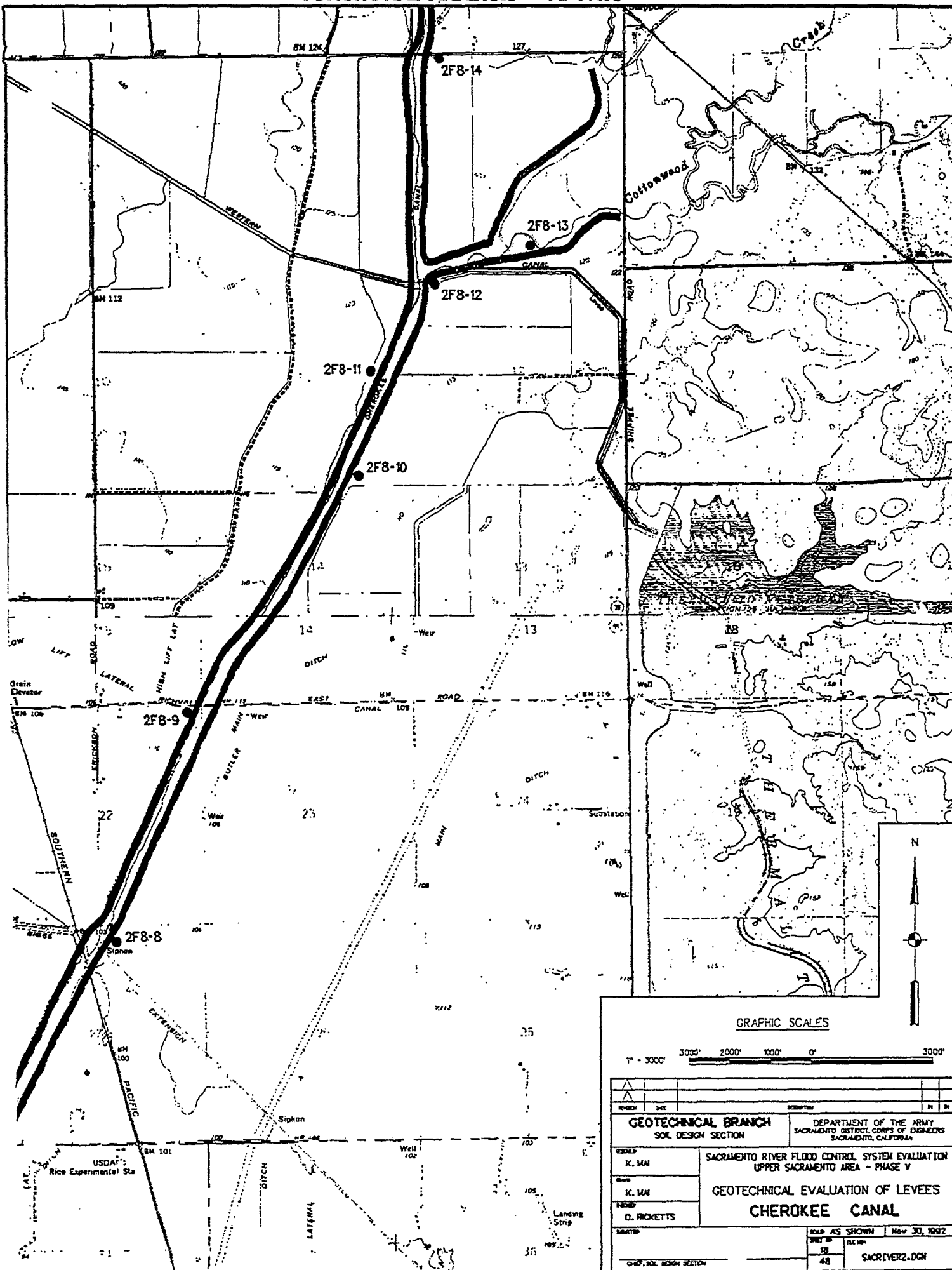
C - 1 0 3 9 1 0

C-103910

GRAPHIC SCALES																	
1" = 3000'	3000' 2000' 1000' 0' 3000'																
<table border="1"> <tr> <td>DATE</td> <td>BY</td> <td>REVISION</td> <td>BY</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </table>		DATE	BY	REVISION	BY												
DATE	BY	REVISION	BY														
<table border="1"> <tr> <td colspan="2"> GEOTECHNICAL BRANCH SOIL DESIGN SECTION </td> <td colspan="2"> DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA </td> </tr> <tr> <td> DESIGNED BY K. MAI </td> <td colspan="3"> SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V </td> </tr> <tr> <td> CHECKED BY K. MAI </td> <td colspan="3"> GEOTECHNICAL EVALUATION OF LEVEES CHEROKEE CANAL </td> </tr> <tr> <td> APPROVED BY D. RICKETTS </td> <td colspan="3"> DATE AS SHOWN: Nov 30, 1992 FILE NO: 17 48 SACRIVER2.DGN </td> </tr> </table>		GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		DESIGNED BY K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V			CHECKED BY K. MAI	GEOTECHNICAL EVALUATION OF LEVEES CHEROKEE CANAL			APPROVED BY D. RICKETTS	DATE AS SHOWN: Nov 30, 1992 FILE NO: 17 48 SACRIVER2.DGN		
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA															
DESIGNED BY K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V																
CHECKED BY K. MAI	GEOTECHNICAL EVALUATION OF LEVEES CHEROKEE CANAL																
APPROVED BY D. RICKETTS	DATE AS SHOWN: Nov 30, 1992 FILE NO: 17 48 SACRIVER2.DGN																

MASTER FILE: 0001 of 0001

FUNCTIONAL ANALYSIS - VE PAYS



GRAPHIC SCALES			
1" = 3000'			
3000' 2000' 1000' 0' 3000'			
GEOTECHNICAL BRANCH SOL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. WAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
DRAWN BY K. WAI	GEOTECHNICAL EVALUATION OF LEVEES CHEROKEE CANAL		
CHECKED BY D. RICKETTS	DATE Nov 30, 1992		
REVISION 1 2 3	18 48 SACRIVER2.DGN		

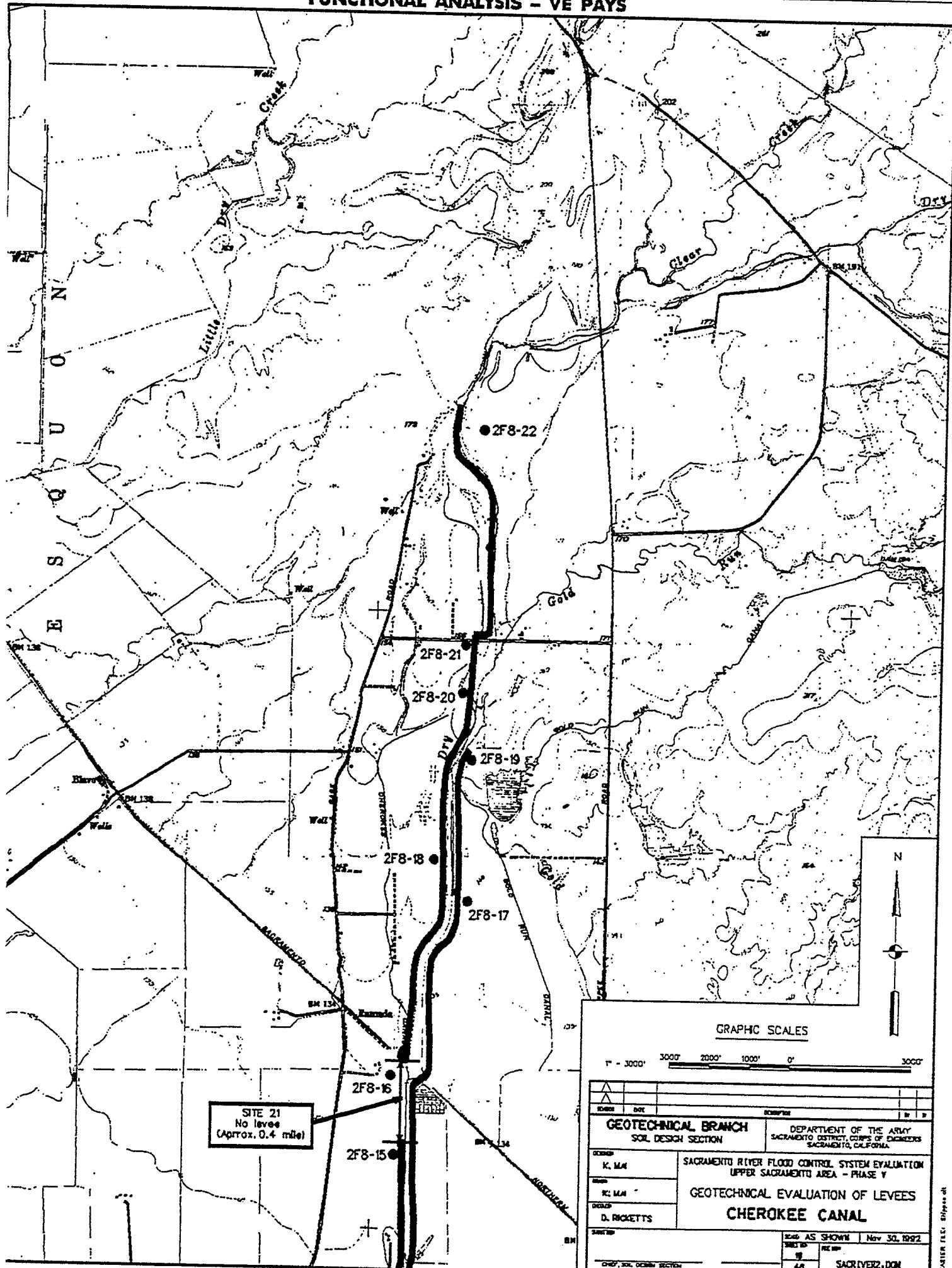
SAFETY PAYS

PLATE 18

C - 1 0 3 9 1 1

C-103911

FUNCTIONAL ANALYSIS - VE PAYS



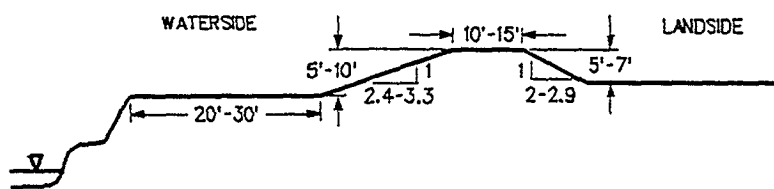
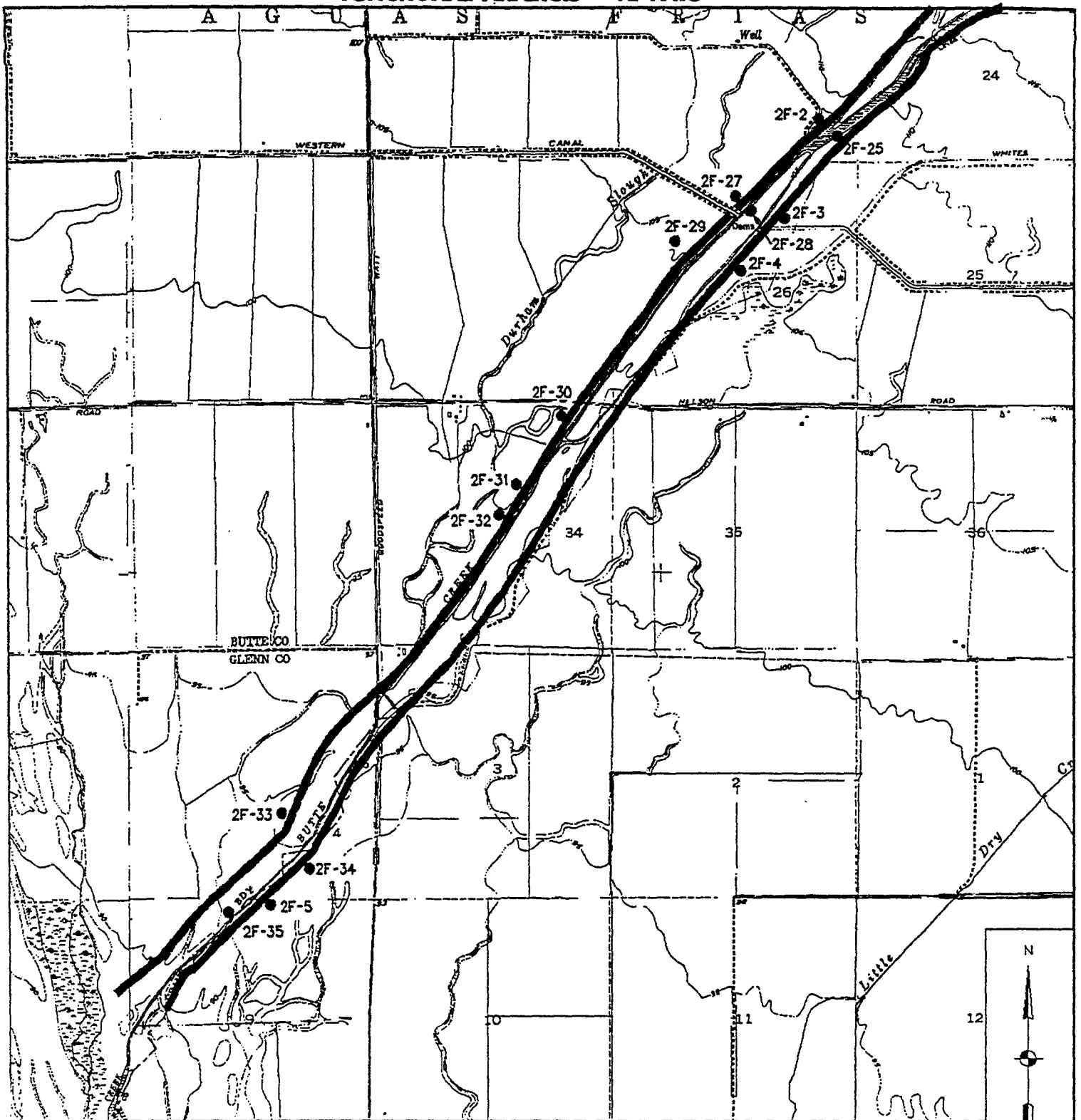
SAFETY PAYS

PLATE 19

C - 1 0 3 9 1 2

GRAPHIC SCALES							
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NO.	DATE	REVISION					
GEOTECHNICAL BRANCH SOIL DESIGN SECTION							
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA							
DESIGNED K. MAH	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V						
CHECKED R. MAH	GEOTECHNICAL EVALUATION OF LEVEES CHEROKEE CANAL						
DESIGNED D. RICKETTS	DRAWN AS SHOWN Nov. 30, 1992						
CHECKED D. RICKETTS	REVISION 1 48						
SACRIVER2.DGN							

FUNCTIONAL ANALYSIS - VE PAYS

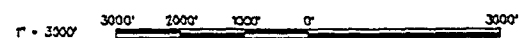


TYPICAL LEVEE CROSS SECTION

SCALE: 1" = 30'



GRAPHIC SCALES



GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
DRAWN BY K. MAI	GEOTECHNICAL EVALUATION OF LEVEES BUTTE CREEK		
CHECKED BY D. RICKETTS	DATE AS SHOWN 20 48		
SHEET NO. 20		FILE NO. SACRIVER2.DGN	

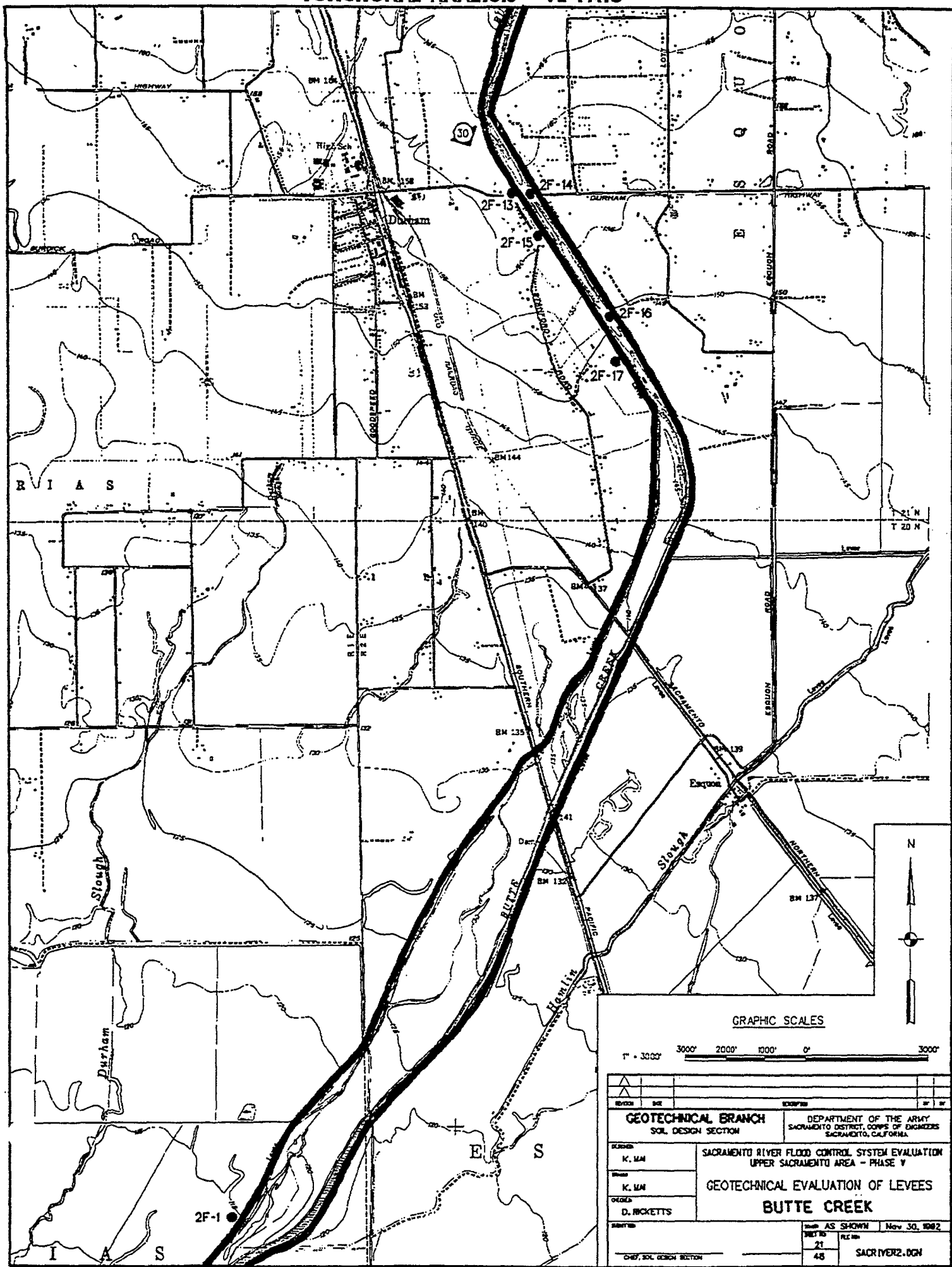
SAFETY PAYS

PLATE 20

C - 1 0 3 9 1 3

C-103913

FUNCTIONAL ANALYSIS - VE PAYS

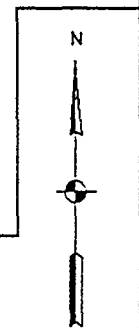
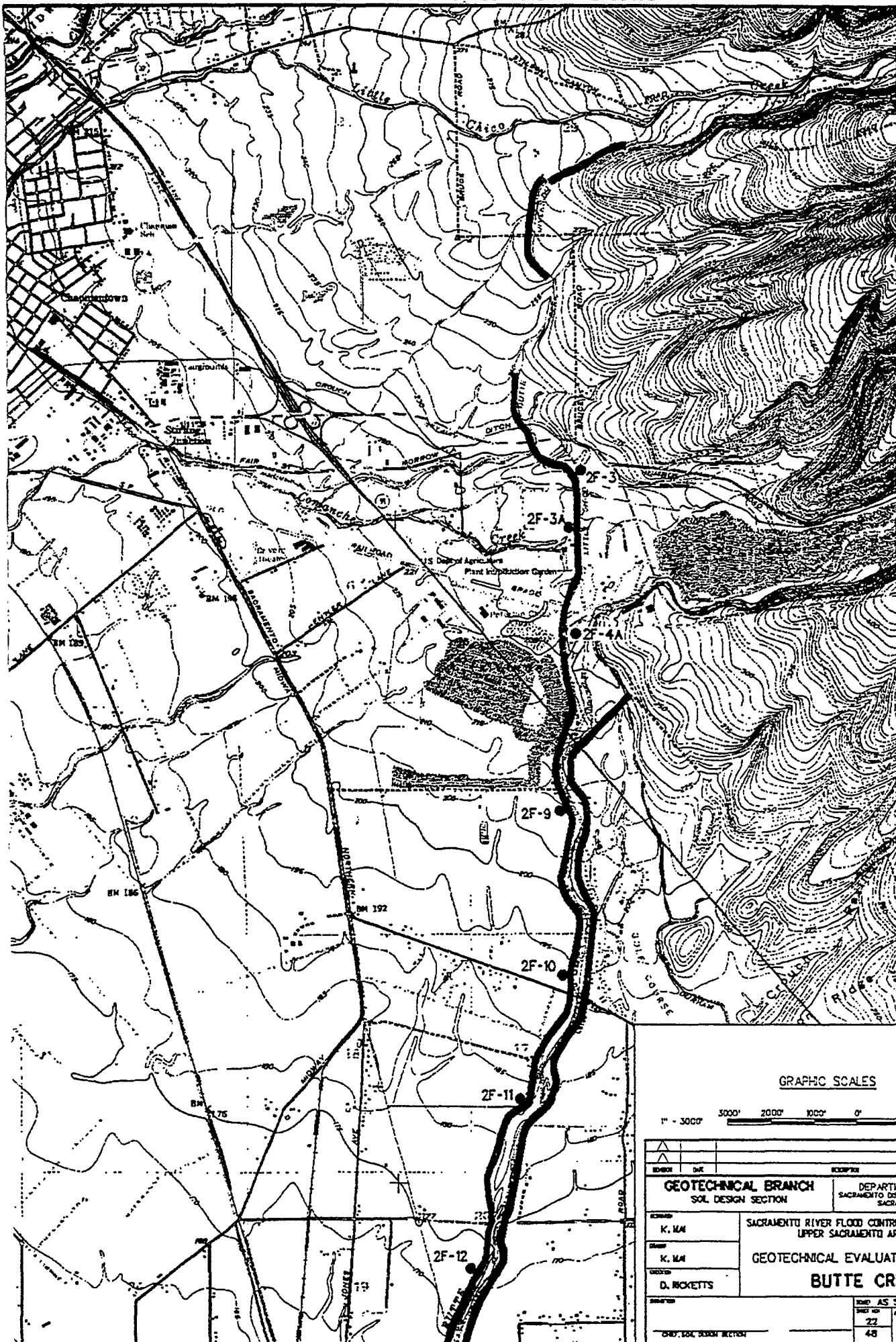


SAFETY PAYS

PLATE 21

C-103914

C-103914



GRAPHIC SCALES

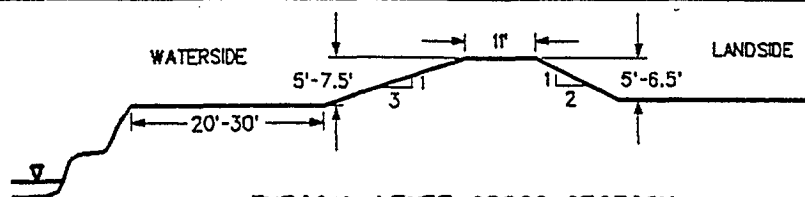
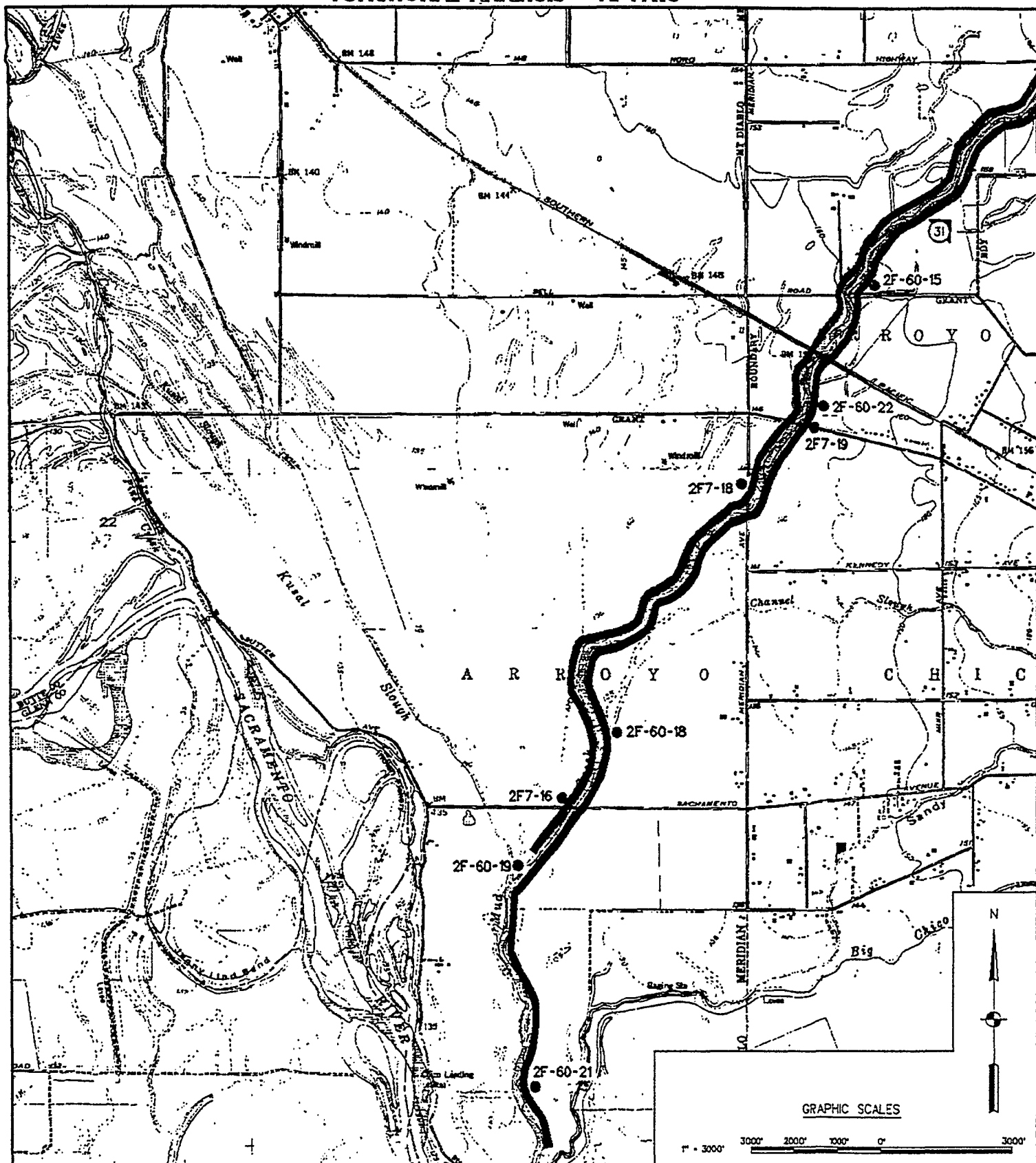
1" = 3000' 3000' 2000' 1000' 0' 3000'

REVISION		DATE		DESCRIPTION		BY		PR	
GEOTECHNICAL BRANCH SOL DESIGN SECTION					DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA				
DESIGNED K. M.A.		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V							
CHECKED K. M.A.		GEOTECHNICAL EVALUATION OF LEVEES BUTTE CREEK							
DRAWN D. RICKETTS		SCALE AS SHOWN		DATE Nov 30, 1992		SHEET NO. 22		FILE NO. SACRIVER2.DGN	
CHIEF, SOL. DESIGN SECTION									

SAFETY PAYS

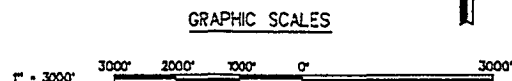
PLATE 22

C - 1 0 3 9 1 5



TYPICAL LEVEE CROSS SECTION

SCALES: 1" = 30'



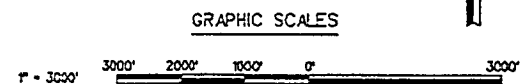
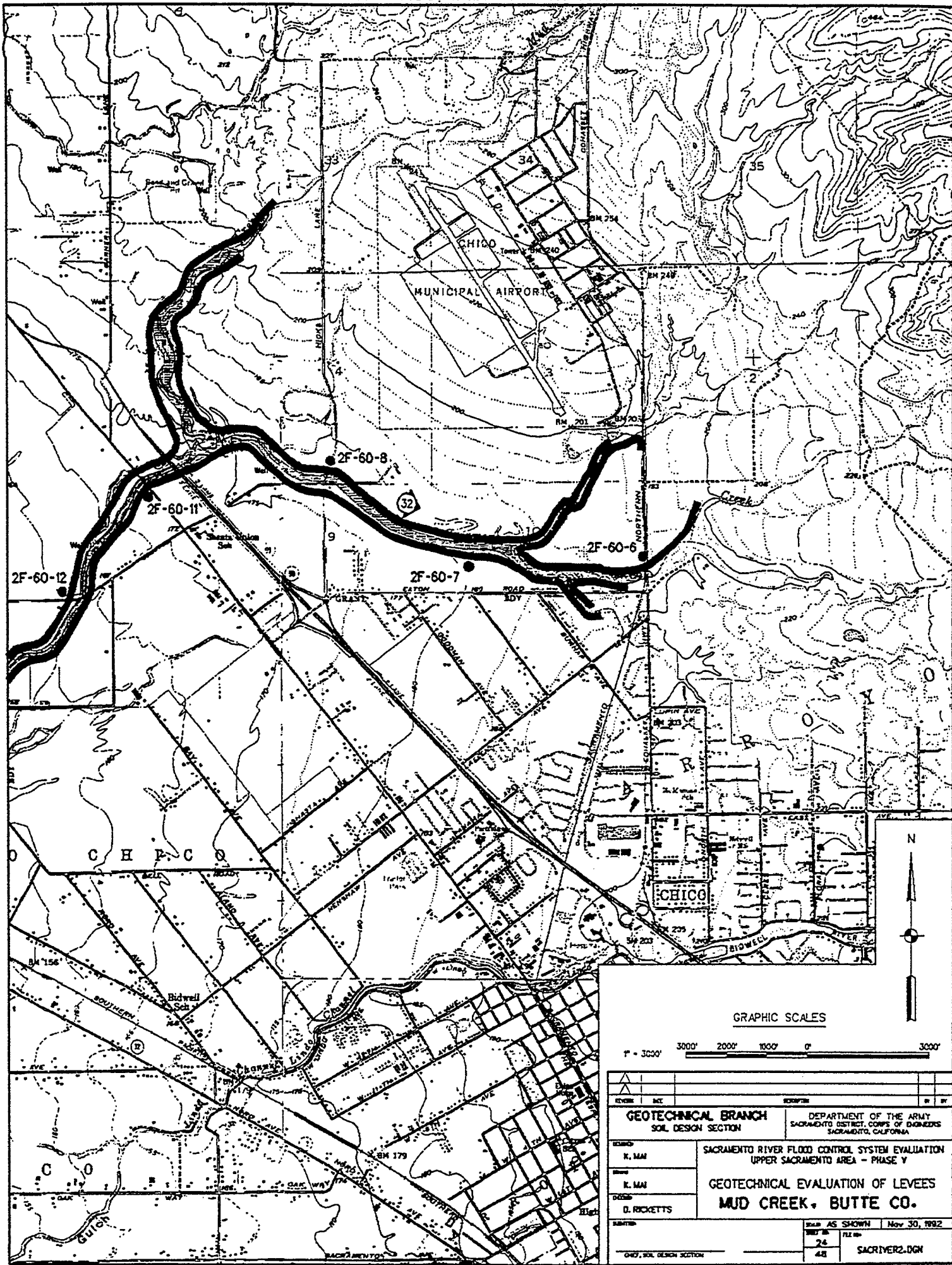
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
CHECKED BY K. MAI	GEOTECHNICAL EVALUATION OF LEVEES MUD CREEK, BUTTE CO.		
DESIGNED BY D. RICKETTS	DRAWN BY AS SHOWN		
DATE 25		SCALE 48	
SHEET NO. 25		DATE NOV 30, 1992	
DRAWN BY 48		FILE NO. SACR1VER2.DGN	

SAFETY PAYS

PLATE 23

C - 1 0 3 9 1 6

C-103916



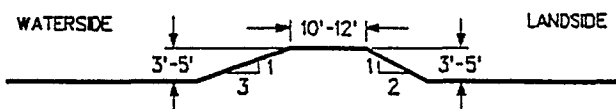
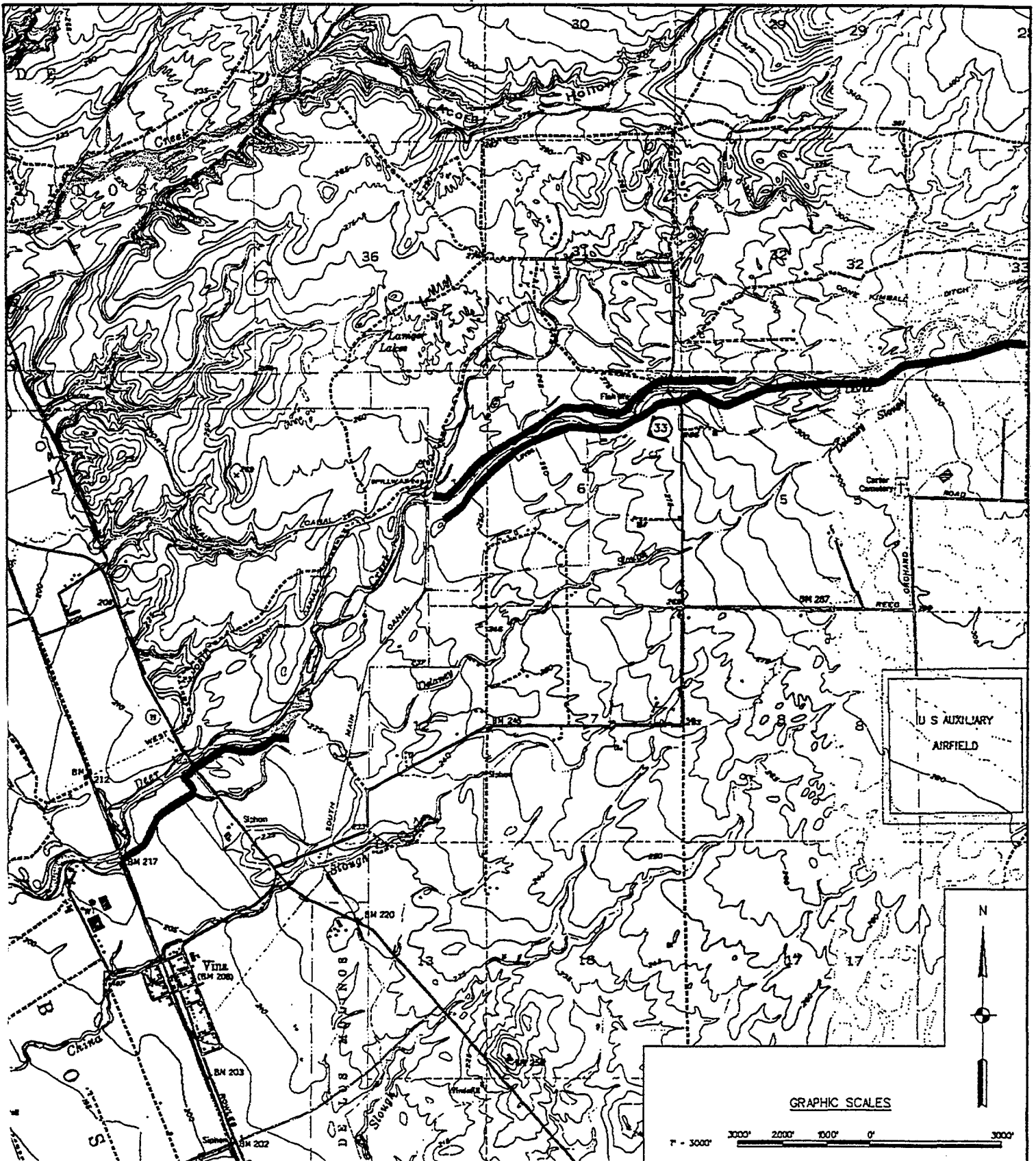
REVISION		DATE	DESCRIPTION	BY	CHK
GEOTECHNICAL BRANCH SOIL DESIGN SECTION					
DRAWN BY K. MAI			DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		
CHECKED BY K. MAI			SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
DESIGNED BY D. RICKETTS			GEOTECHNICAL EVALUATION OF LEVEES MUD CREEK, BUTTE CO.		
APPROVED BY (Signature)			SCALE AS SHOWN 24 48		
DATE NOV 30, 1992			FILE NO. SACRIVER2.DGN		

SAFETY PAYS

PLATE 24

C-103917

C-103917



SCALES: 1" = 30'

GRAPHIC SCALES

1" = 3000'

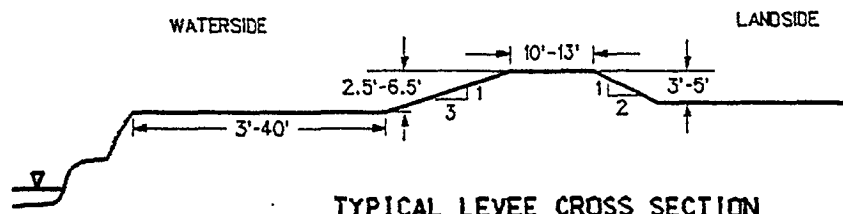
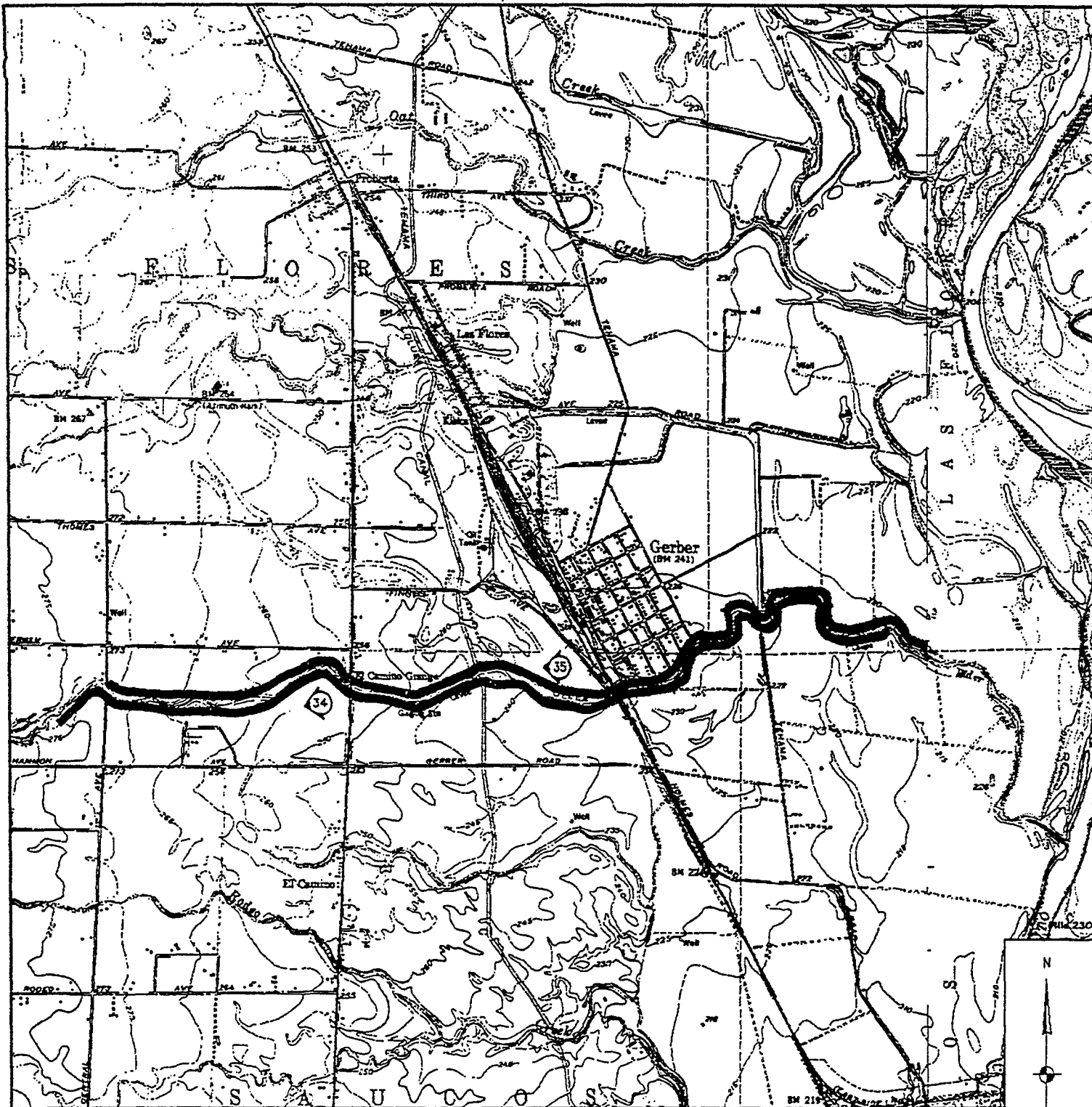
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
NAME K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
DESIGN K. MAI	GEOTECHNICAL EVALUATION OF LEVEES DEER CREEK, TEHAMA CO.		
CHECKED D. RICKETTS	DATE Nov 30, 1992	SCALE 25'	FILE NO. 48
DRAWN BY SOIL DESIGN SECTION		SACRIVER2.DGN	

SAFETY PAYS

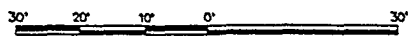
PLATE 25

C-103918

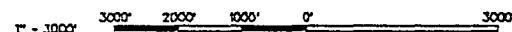
C-103918



SCALE: 1" = 30'



GRAPHIC SCALES



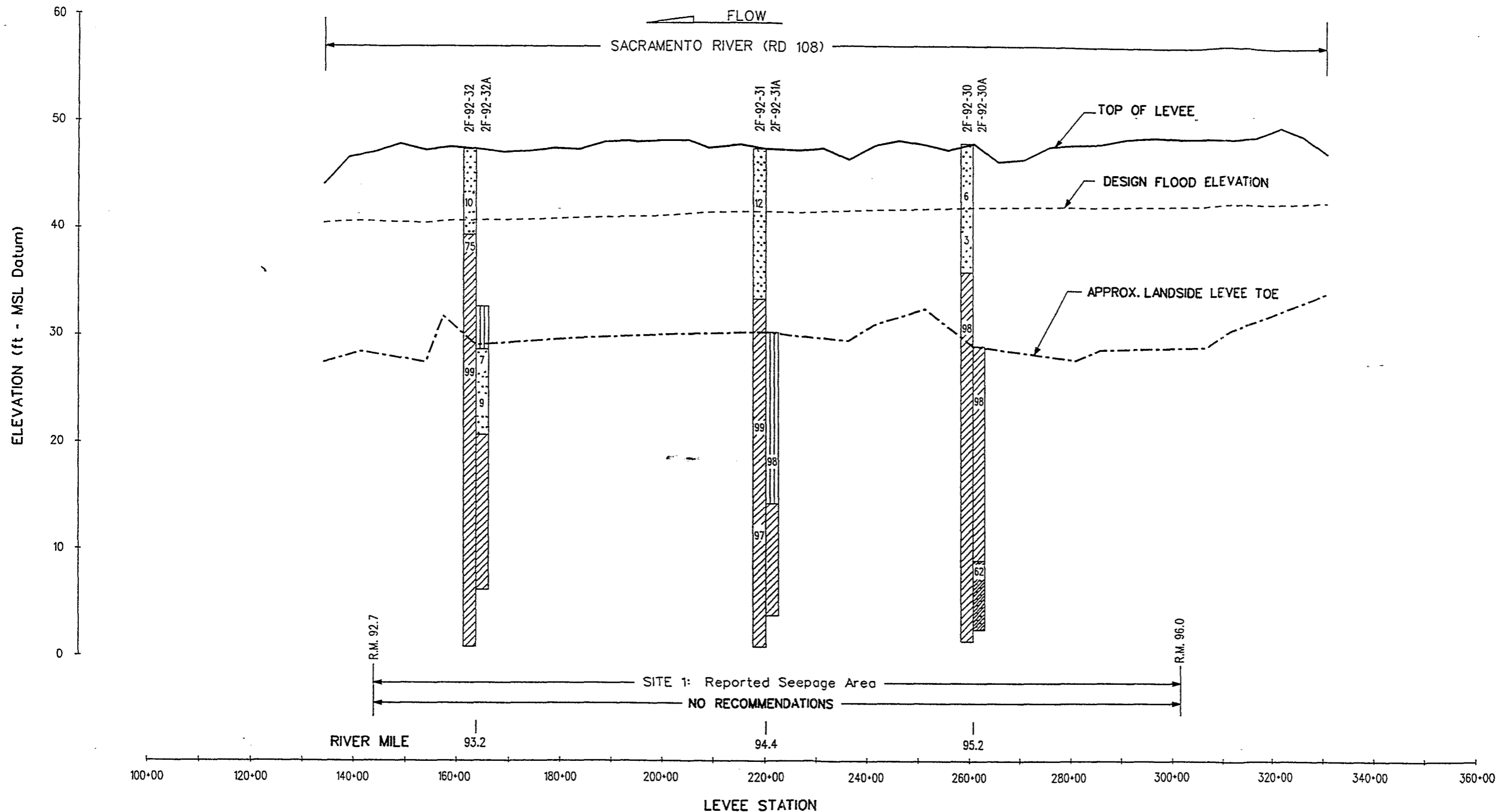
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNER K. MA	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
CHECKED K. MA	GEOTECHNICAL EVALUATION OF LEVEES ELDER CREEK, TEHAMA CO.		
SUBMITTED D. RICKETTS	DATE AS SHOWN 26	FILE NO. 48	DATE Nov 30, 1992
CADD, SOIL DESIGN SECTION		SACRIVER2.DGN	

SAFETY PAYS

PLATE 26

C - 1 0 3 9 1 9

C-103919

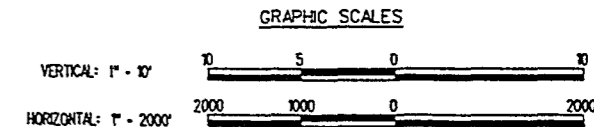


LEGEND

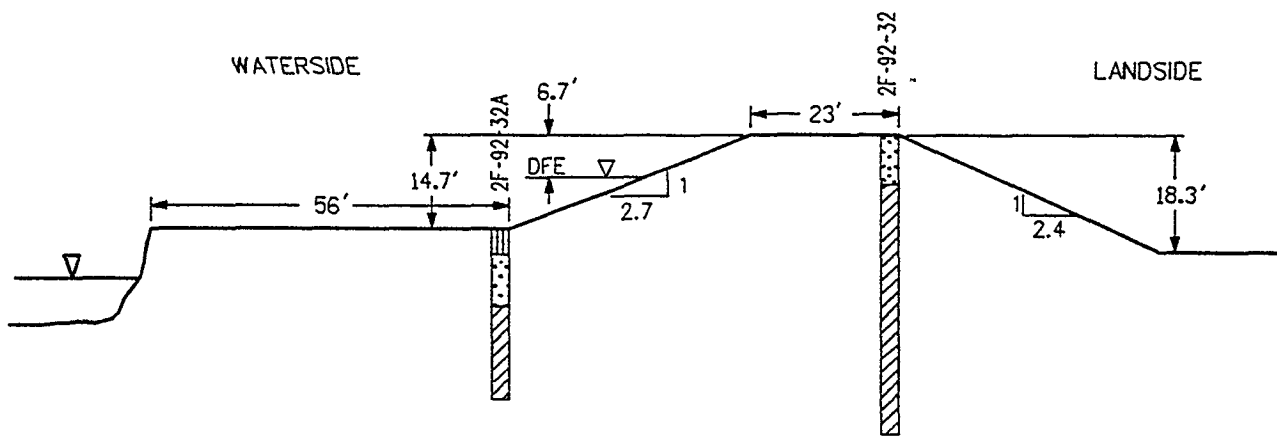
- Silt (ML, >70% fines)
- Silty sand or sandy silt (SM, 12% - 70% fines)
- Clay (CL, >70% fines)
- Clayey sand or sandy clay (SC, 12% - 70%, fines)
- Sand (SP, <12% fines)
- Percentage of fines (-200 sieve size) per laboratory testing

NOTES

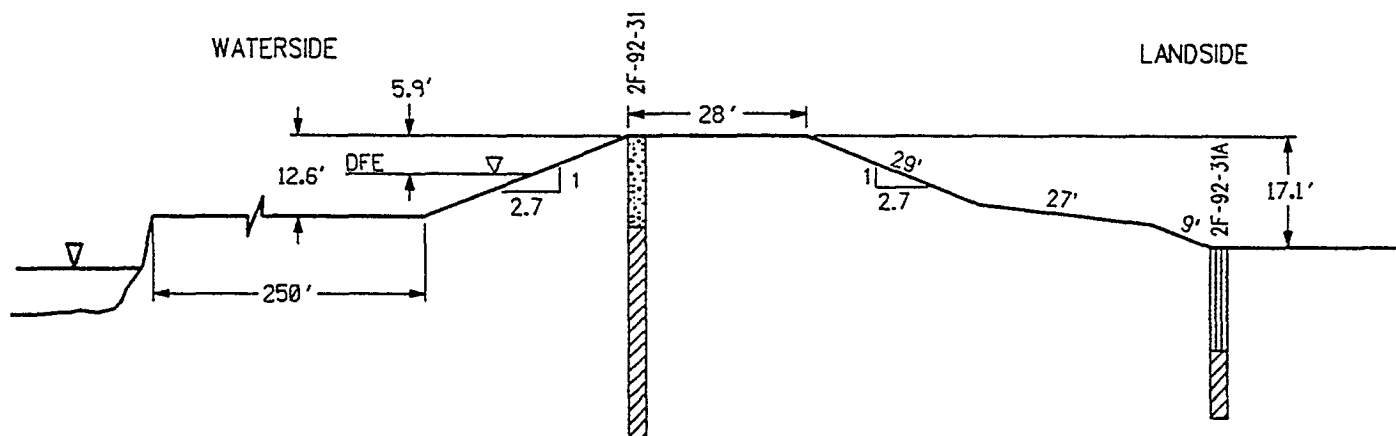
1. Soil classification are based on ECPT data - soil correlations for ECPT borings (i.e. 2F-92-*), or field descriptions and lab data for auger borings (i.e. 2F-92-*).
2. Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).



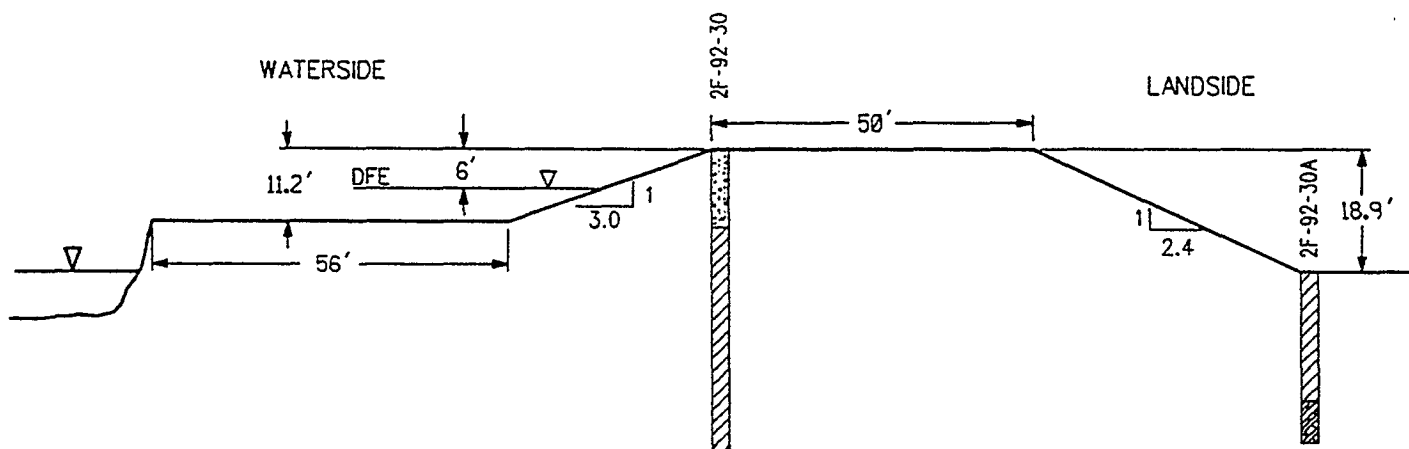
GEOTECHNICAL BRANCH		DEPARTMENT OF THE ARMY	
SOIL DESIGN SECTION		SACRAMENTO DISTRICT, CORPS OF ENGINEERS	
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION		SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAI	UPPER SACRAMENTO AREA - PHASE V		
DESIGNED BY K. MAI	GEOTECHNICAL EVALUATION OF LEVEES		
DESIGNED BY D. RICKETTS	LEVEE PROFILES, SACRAMENTO RIVER		
SITE 1		Nov 30, 1992	
SCALE AS SHOWN		PROFILES.DGN	
27		50	



STATION 163+99 (R.M. 93.2)

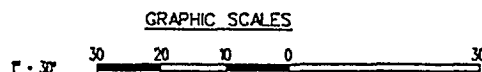


STATION 220+29 (R.M. 94.4)



STATION 260+93 (R.M. 95.2)

DFE: Design Flood Elevation



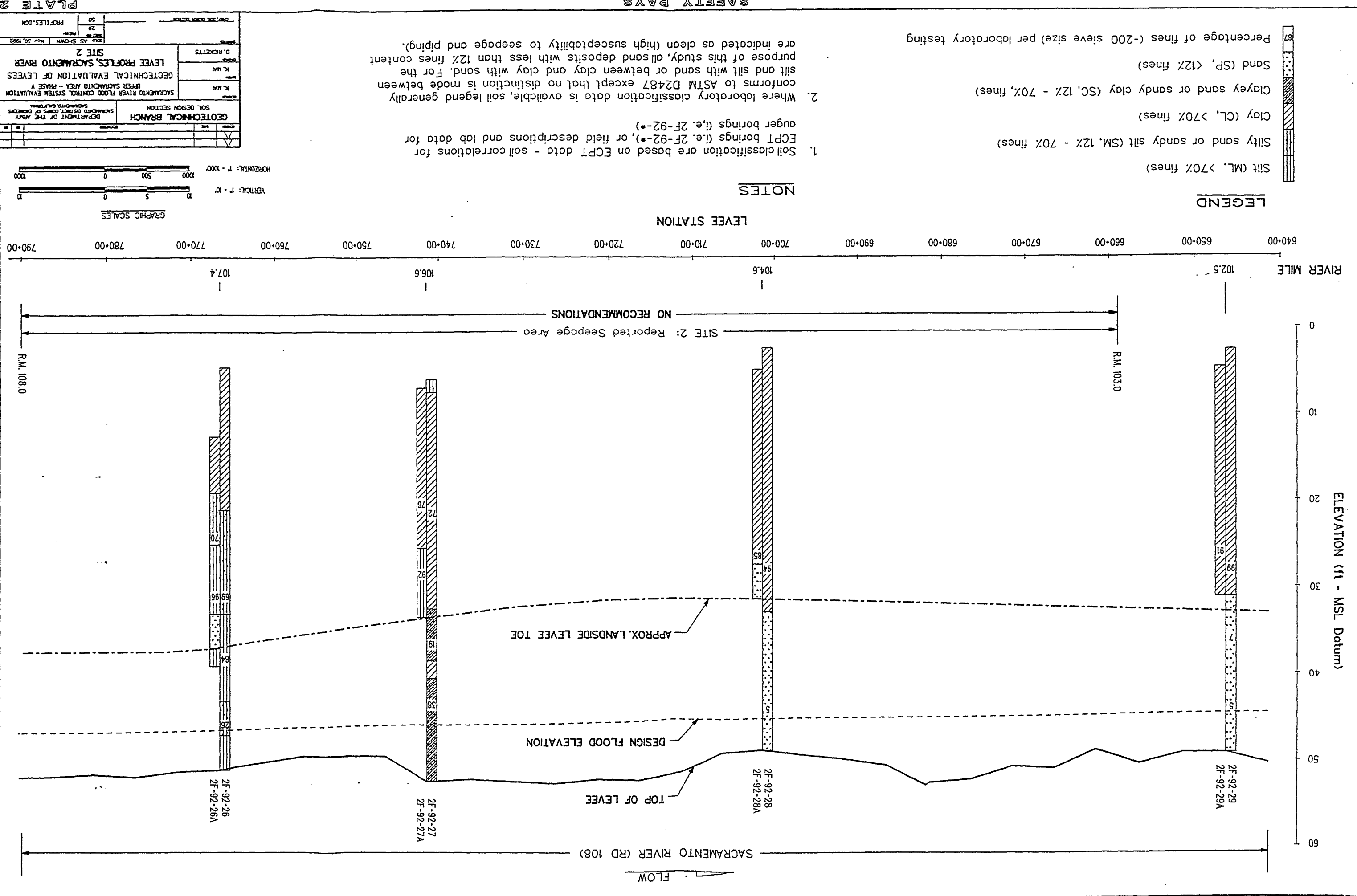
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
CHECKED BY K. MAI	GEOTECHNICAL EVALUATION OF LEVEES		
DRAWN BY D. RICKETTS	CROSS SECTIONS, SACRAMENTO RIVER SITE 1		
DATE Nov 30, 1992	SHEET NO. 28	FILE NO. 50	PROFILES.DGN

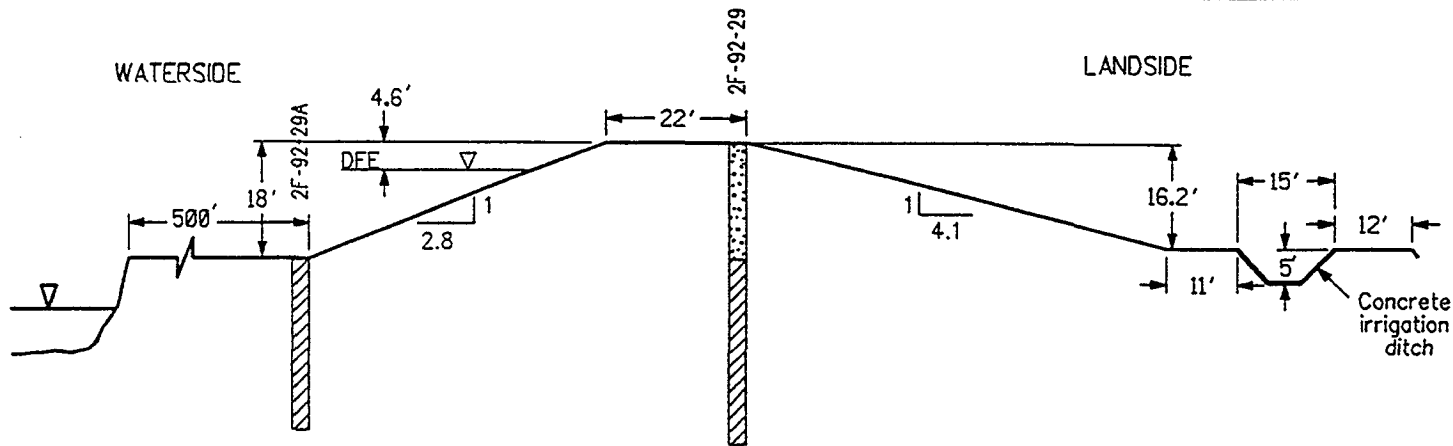
SAFETY PAYS

PLATE 28

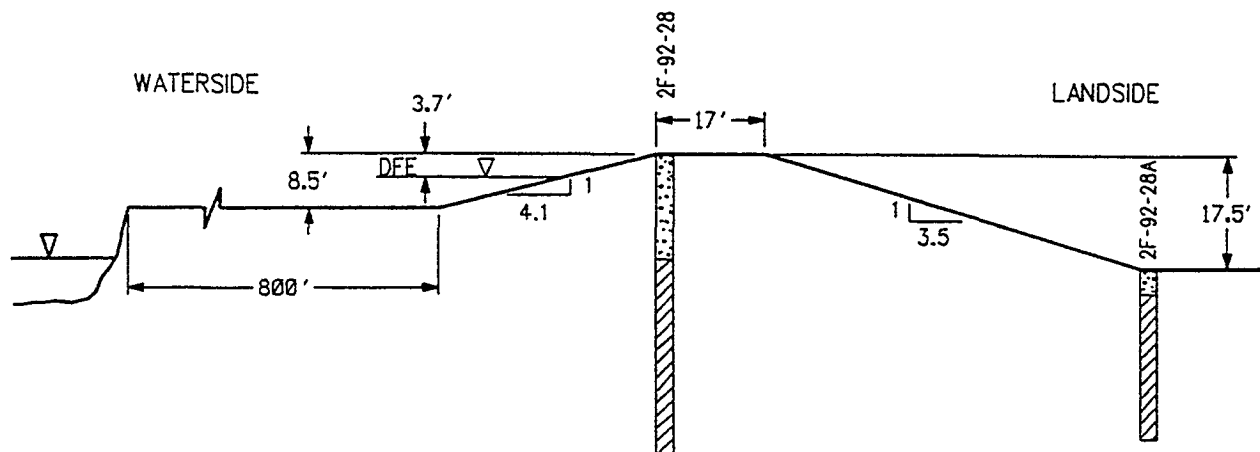
C-103921

C-103921

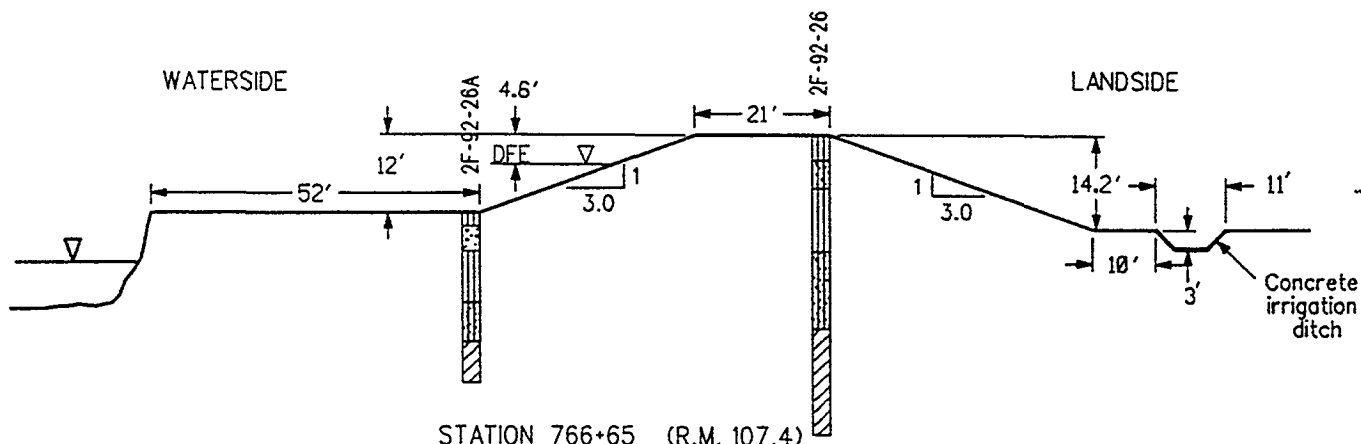




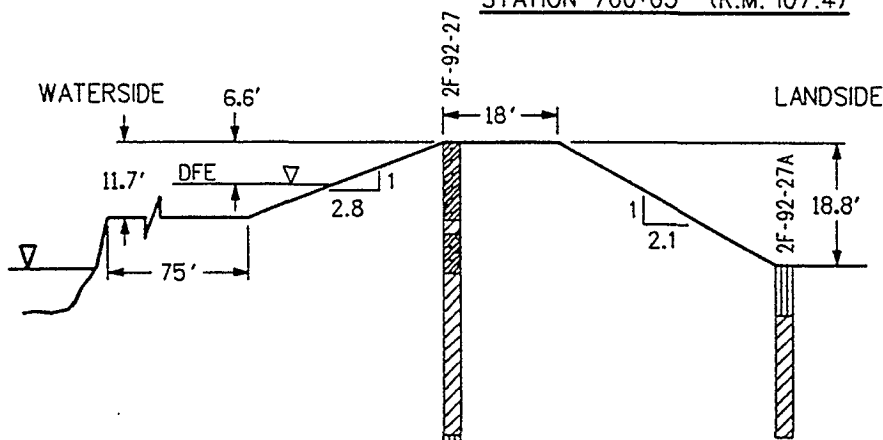
STATION 646+58 (R.M. 102.5)



STATION 701+56 (R.M. 104.6)



STATION 766+65 (R.M. 107.4)



STATION 741+56 (R.M. 106.6)

DFE: Design Flood Elevation

GRAPHIC SCALES



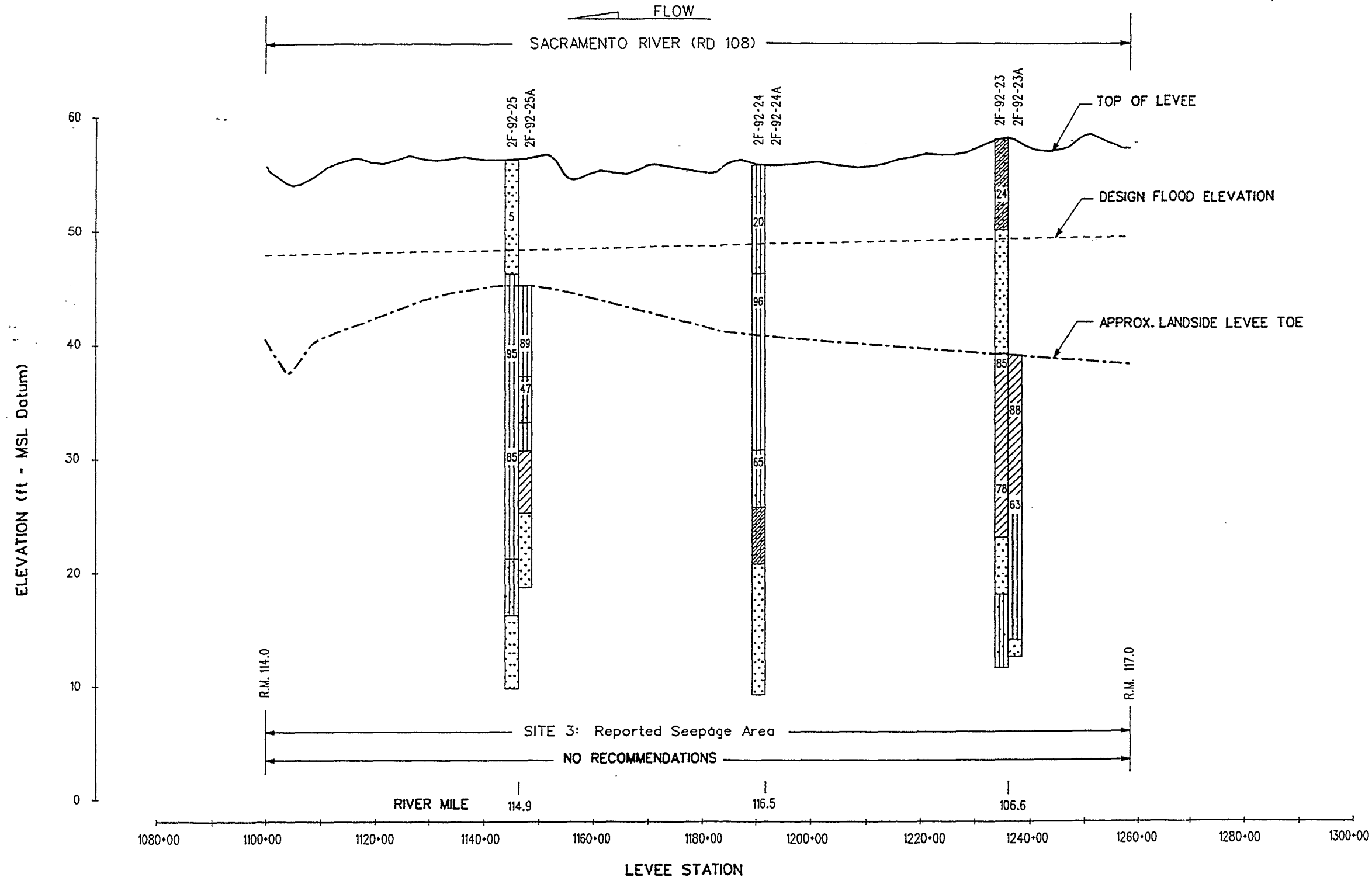
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES CROSS SECTIONS, SACRAMENTO RIVER SITE 2		
CHECKED BY K. MAI			
DESIGNED BY D. RICKETTS			
DRAWN BY K. MAI		SCALE AS SHOWN	DATE Nov 30, 1992
SHEET NO. 30		OF 50	
FILE NO. 50		PROJECT PROFILES.DGN	

SAFETY PAYS

PLATE 30

C - 1 0 3 9 2 3

C-103923



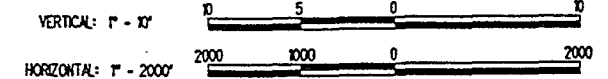
LEGEND

- Silt (ML, >70% fines)
- Silty sand or sandy silt (SM, 12% - 70% fines)
- Clay (CL, >70% fines)
- Clayey sand or sandy clay (SC, 12% - 70%, fines)
- Sand (SP, <12% fines)
- Percentage of fines (-200 sieve size) per laboratory testing

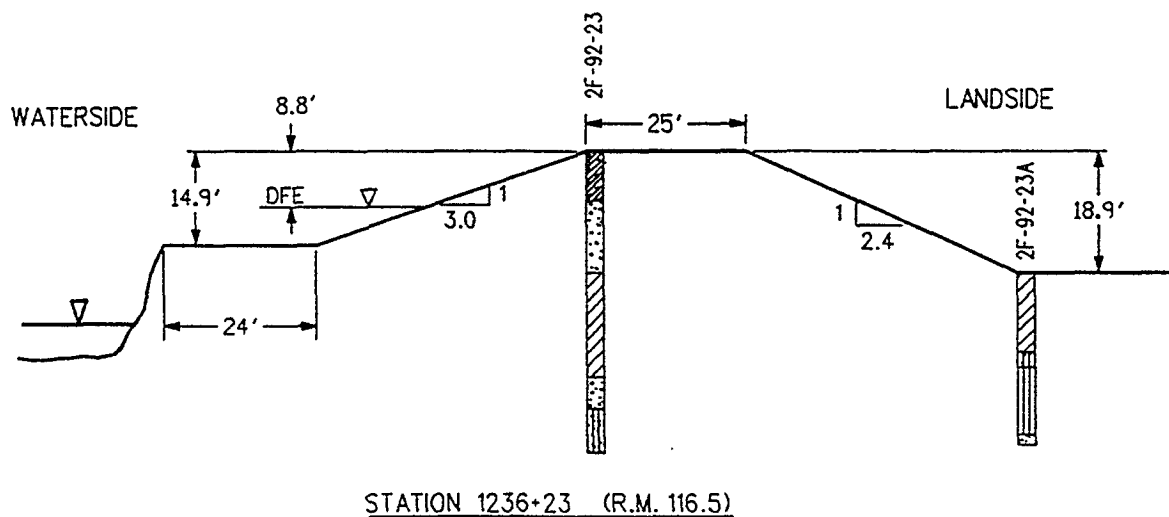
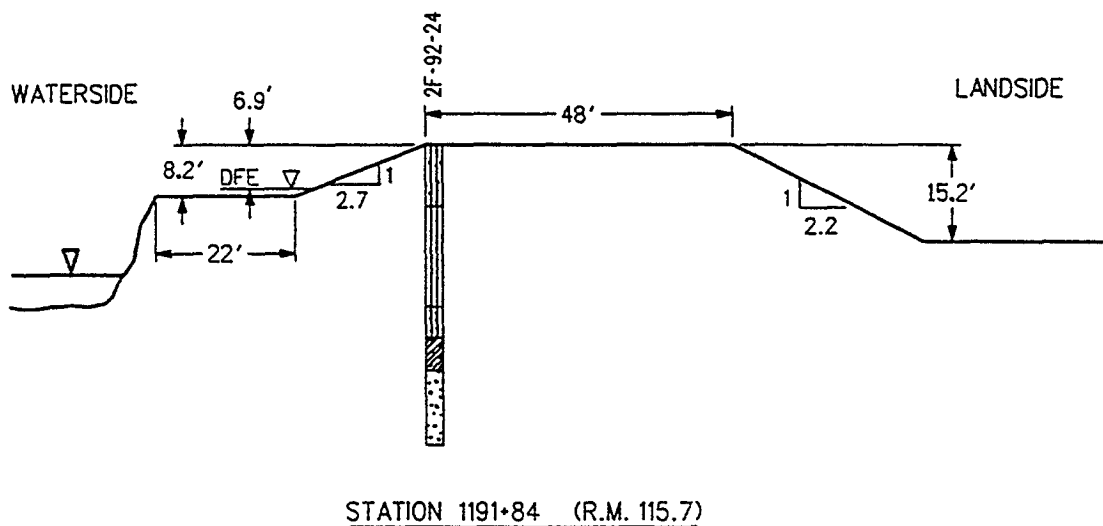
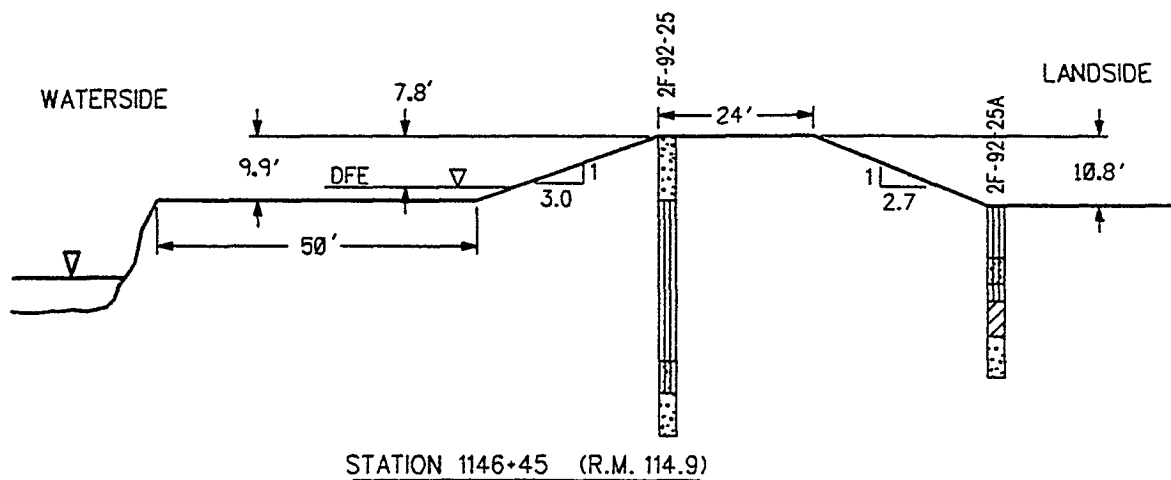
NOTES

1. Soil classification are based on ECPT data - soil correlations for ECPT borings (i.e. 2F-92-*), or field descriptions and lab data for auger borings (i.e. 2F-92-*).
2. Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).

GRAPHIC SCALES



GEOTECHNICAL BRANCH		DEPARTMENT OF THE ARMY	
SOIL DESIGN SECTION		SACRAMENTO DISTRICT, CORPS OF ENGINEERS	
K. MA		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION	
K. MA		UPPER SACRAMENTO AREA - PHASE V	
D. RICKETTS		GEOTECHNICAL EVALUATION OF LEVEES	
		LEVEE PROFILES, SACRAMENTO RIVER	
		SITE 3	
DATE: AS SHOWN		Nov 30, 1992	
SHEET: 31		REV: 00	
DRAWN: SOIL DESIGN SECTION		PROFILES.DGN	



DFE: Design Flood Elevation

GRAPHIC SCALES



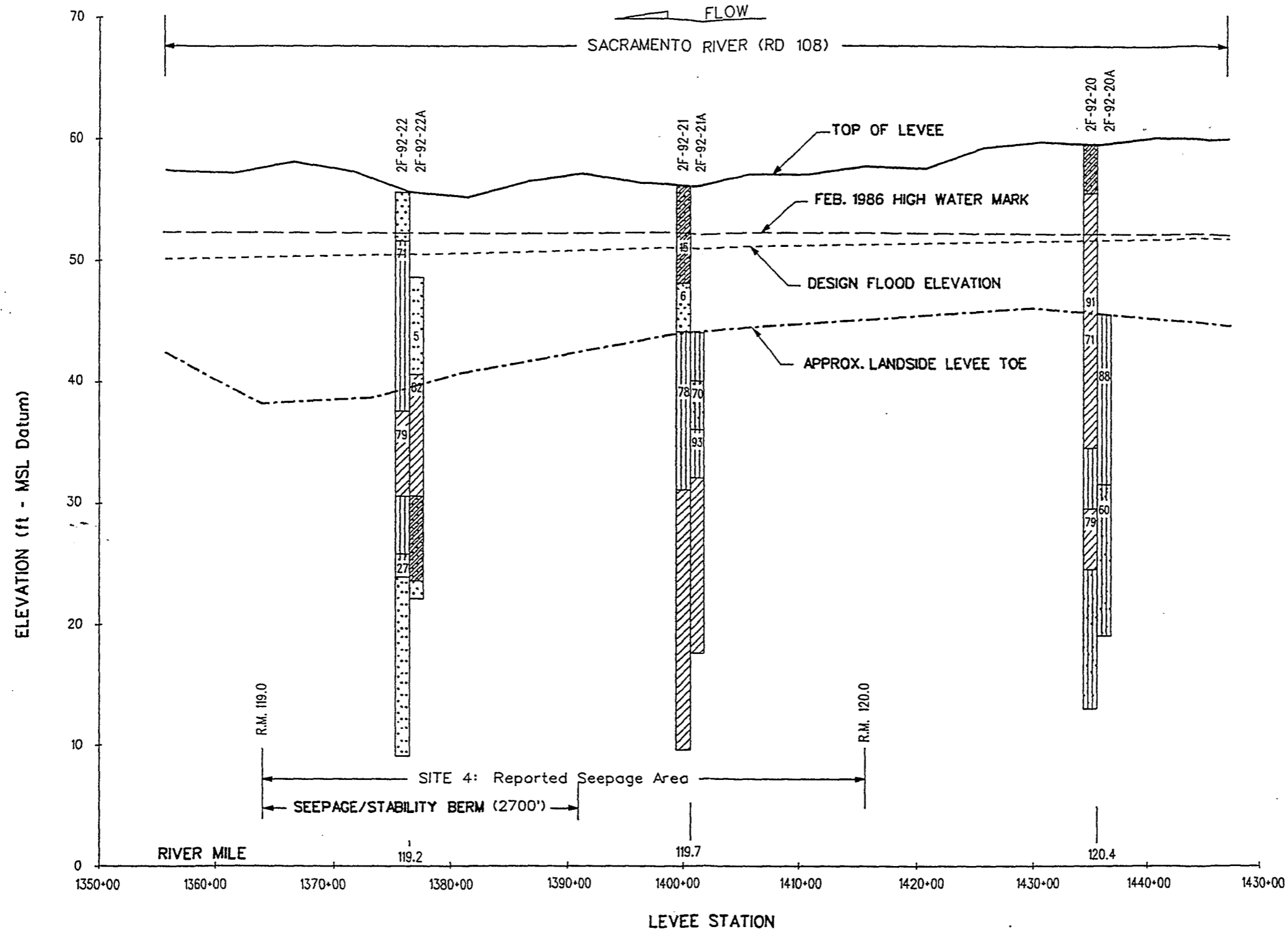
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
K. MAN K. MAN D. RICKETTS		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES CROSS SECTIONS, SACRAMENTO RIVER SITE 3	
DATE: _____ DRAWN BY: _____ CHECKED BY: _____		SCALE: AS SHOWN DATE: Nov 30, 1992 FILE NO: 32 50 PROFILES.DGN	

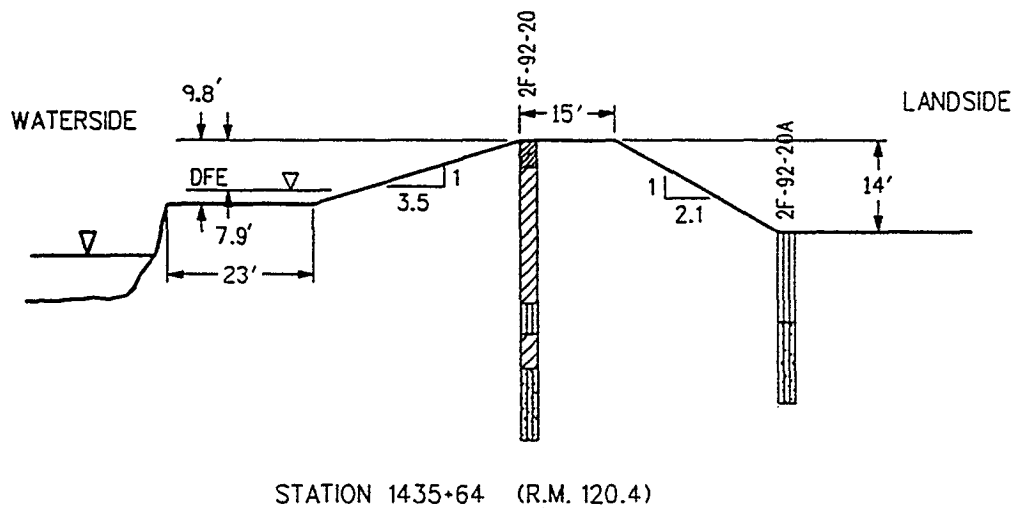
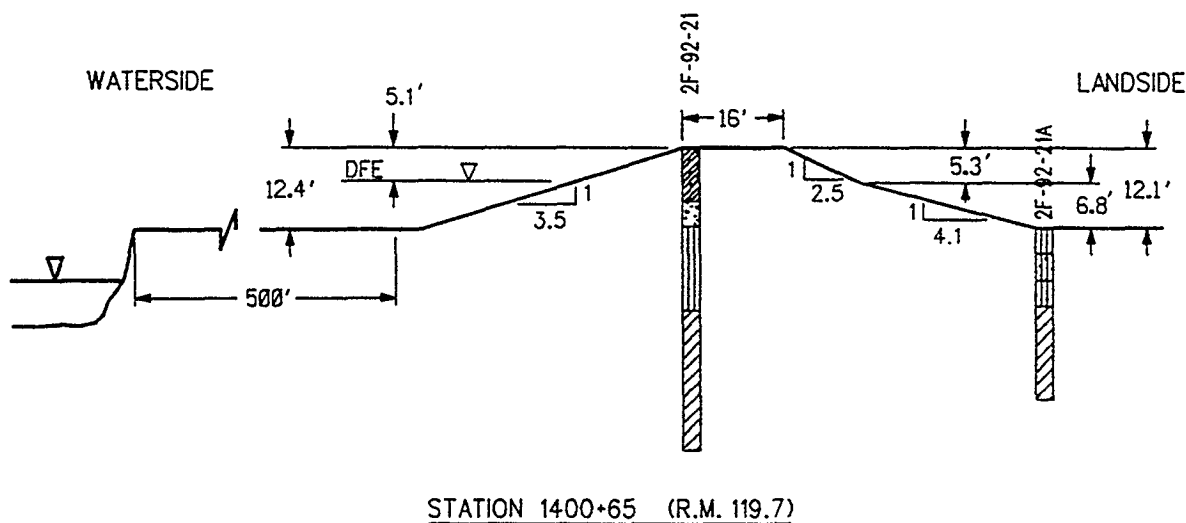
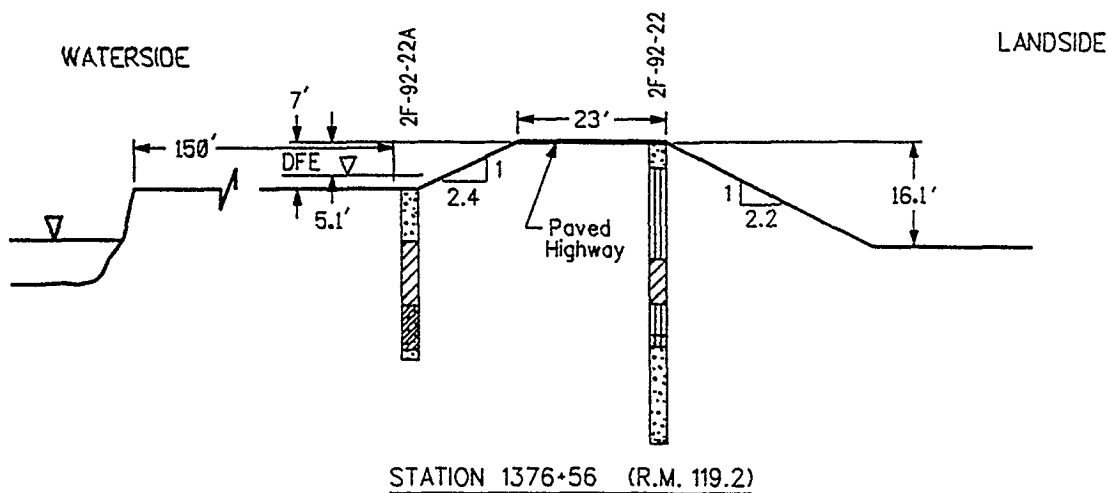
SAFETY PAYS

PLATE 32

C - 1 0 3 9 2 5

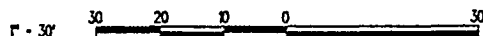
C-103925





DFE: Design Flood Elevation

GRAPHIC SCALES



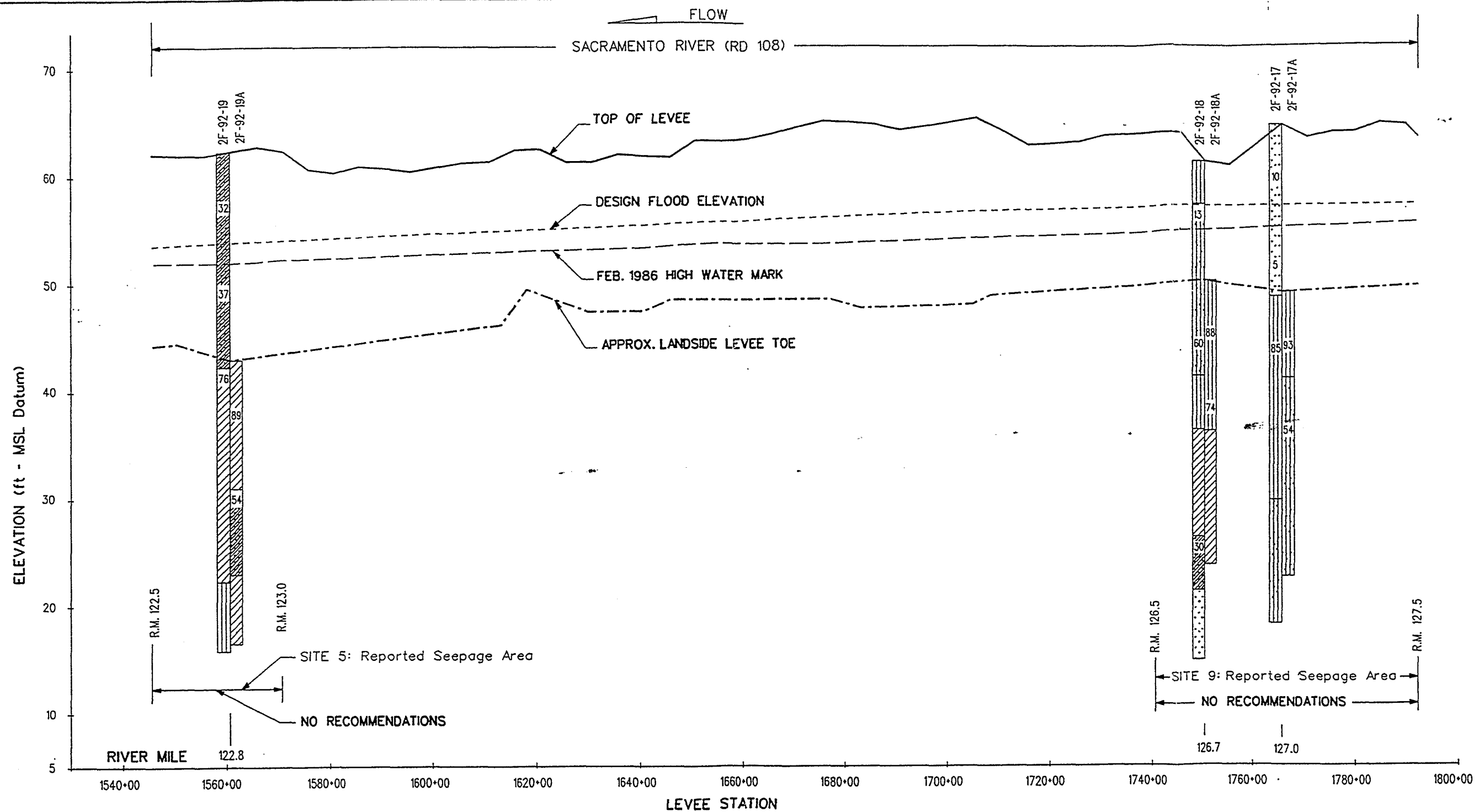
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAN	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
DRAWN BY K. MAN	GEOTECHNICAL EVALUATION OF LEVEES		
CHECKED BY D. RICKETTS	CROSS SECTIONS, SACRAMENTO RIVER SITE 4		
DATE Nov 30, 1992		DRAWN BY PROFILES.DGN	

SAFETY PAYS

PLATE 34

C - 1 0 3 9 2 7

C-103927



LEGEND

- Silt (ML, >70% fines)
- Silty sand or sandy silt (SM, 12% - 70% fines)
- Clay (CL, >70% fines)
- Clayey sand or sandy clay (SC, 12% - 70%, fines)
- Sand (SP, <12% fines)
- Percentage of fines (-200 sieve size) per laboratory testing

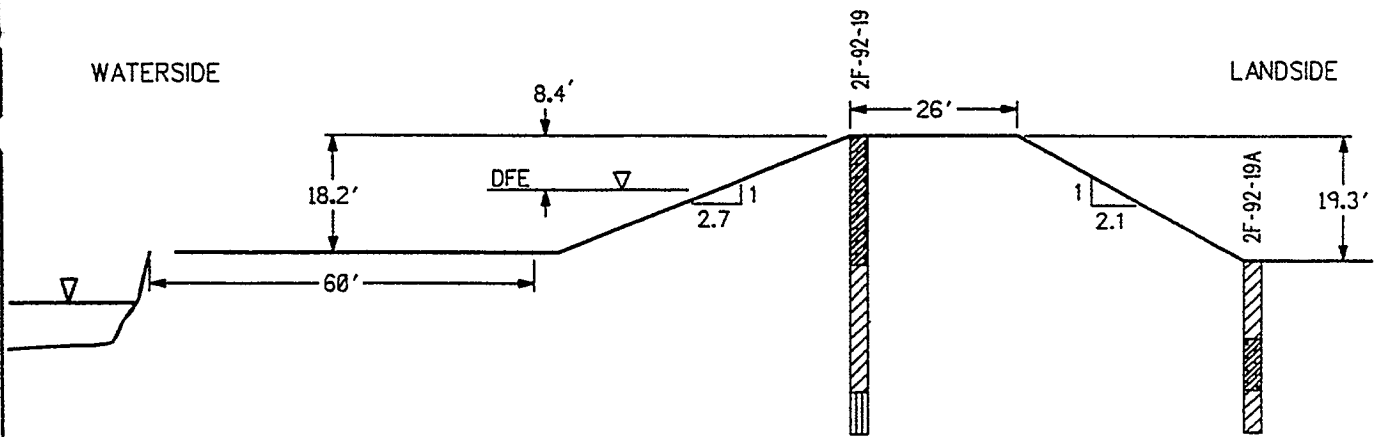
NOTES

- Soil classification are based on ECPT data - soil correlations for ECPT borings (i.e. 2F-92-*), or field descriptions and lab data for auger borings (i.e. 2F-92-*)
- Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).

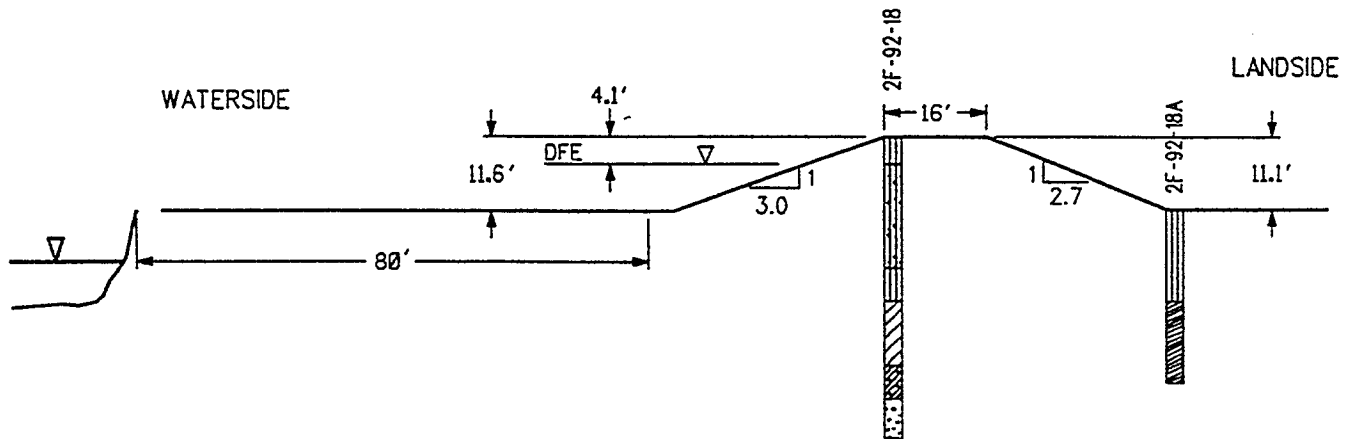
GRAPHIC SCALES

VERTICAL: 1" = 10'
HORIZONTAL: 1" = 2000'

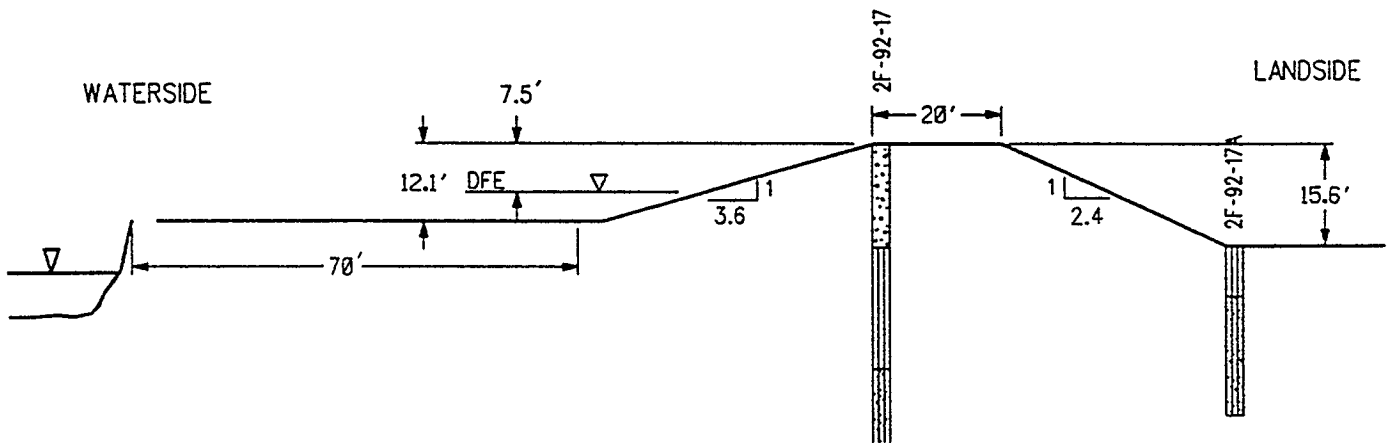
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
K. MAI		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V	
K. MAI		GEOTECHNICAL EVALUATION OF LEVEES	
D. RICKETTS		LEVEE PROFILES, SACRAMENTO RIVER SITE 5 & 9	
DATE: AS SHOWN		Nov 30, 1992	
35		PROFILES-DGN	



SITE 5: STATION 163+99 (R.M. 93.2)



SITE 9: STATION 220+29 (R.M. 94.4)



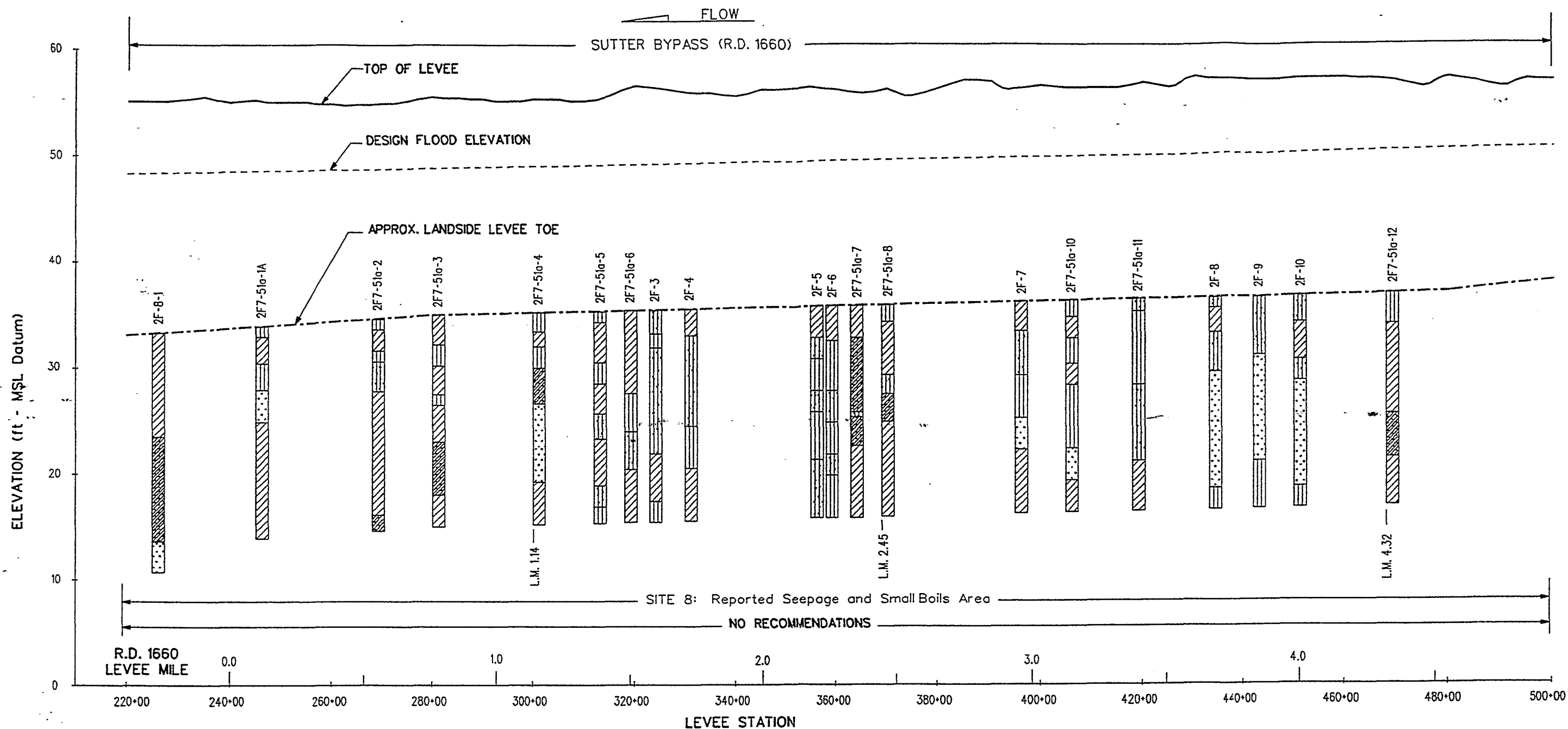
SITE 9: STATION 260+93 (R.M. 95.2)

DFE: Design Flood Elevation

GRAPHIC SCALES



GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAI	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES CROSS SECTIONS, SACRAMENTO RIVER SITE 5 & 9		
CHECKED BY K. MAI	DATE Nov 30, 1992	DRAWN BY D. RICKETTS	FILE NO. 36
SHEET NO. 50		PROJILES2.DGN	



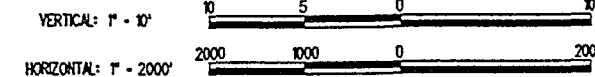
LEGEND

- Silt (ML, >70% fines)
- Silty sand or sandy silt (SM, 12% - 70% fines)
- Clay (CL, >70% fines)
- Clayey sand or sandy clay (SC, 12% - 70%, fines)
- Sand (SP, <12% fines)
- Percentage of fines (-200 sieve size) per laboratory testing

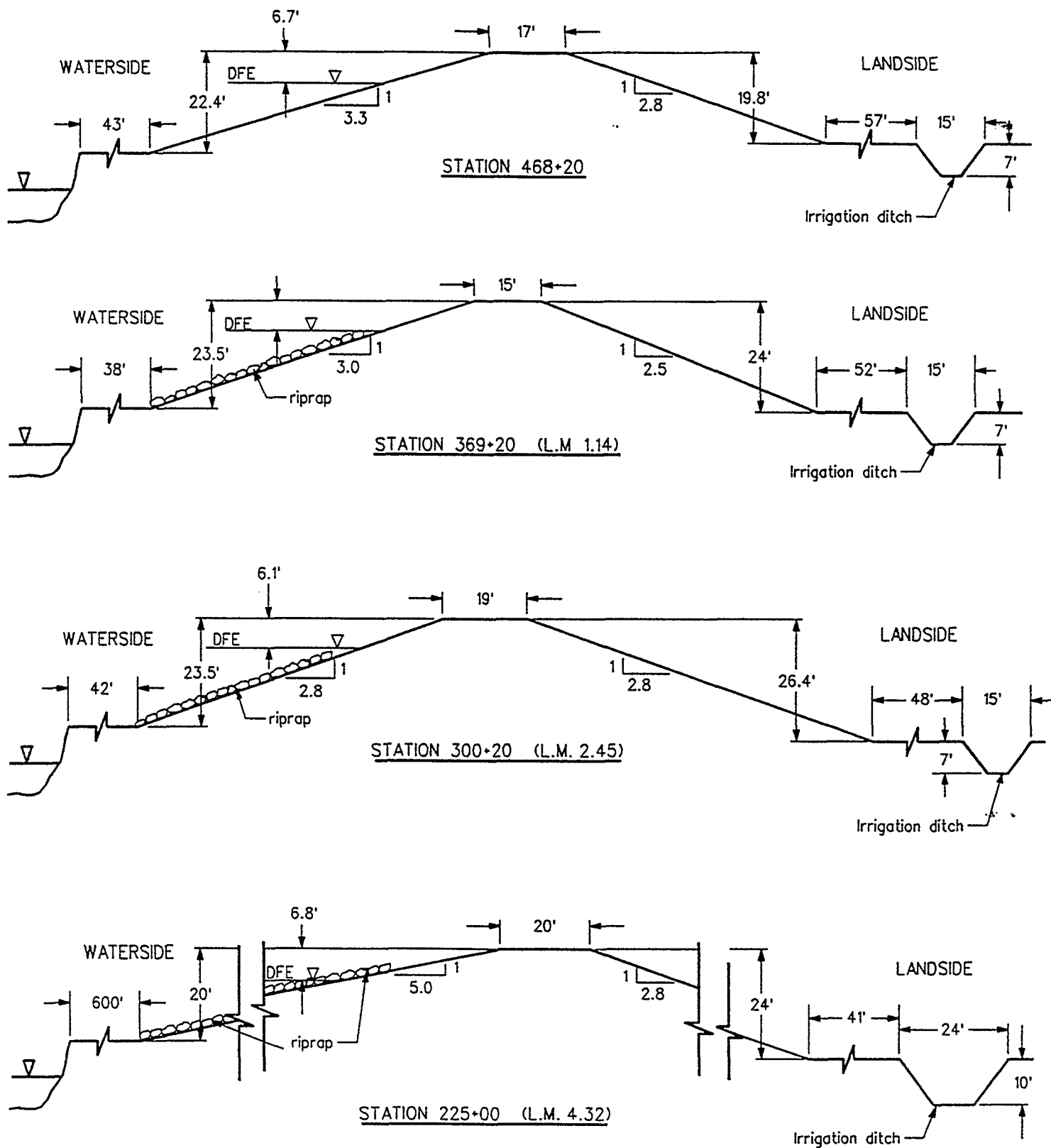
NOTES

1. Soil classification are based on ECPT data - soil correlations for ECPT borings (i.e. 2F-92-*), or field descriptions and lab data for auger borings (i.e. 2F-92-*).
2. Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).

GRAPHIC SCALES



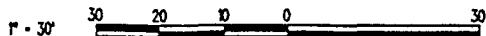
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MA	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
CHECKED BY K. MA	GEOTECHNICAL EVALUATION OF LEVEES		
DESIGNED BY D. RICKETTS	LEVEE PROFILES, SUTTER BYPASS SITE 8		
DATE NOV 30, 1992	SCALE AS SHOWN	FILE NO. 37	PROFILES.DGN



DFE: Design Flood Elevation

L.M.: Reclamation District 1660 Levee Mile

GRAPHIC SCALES



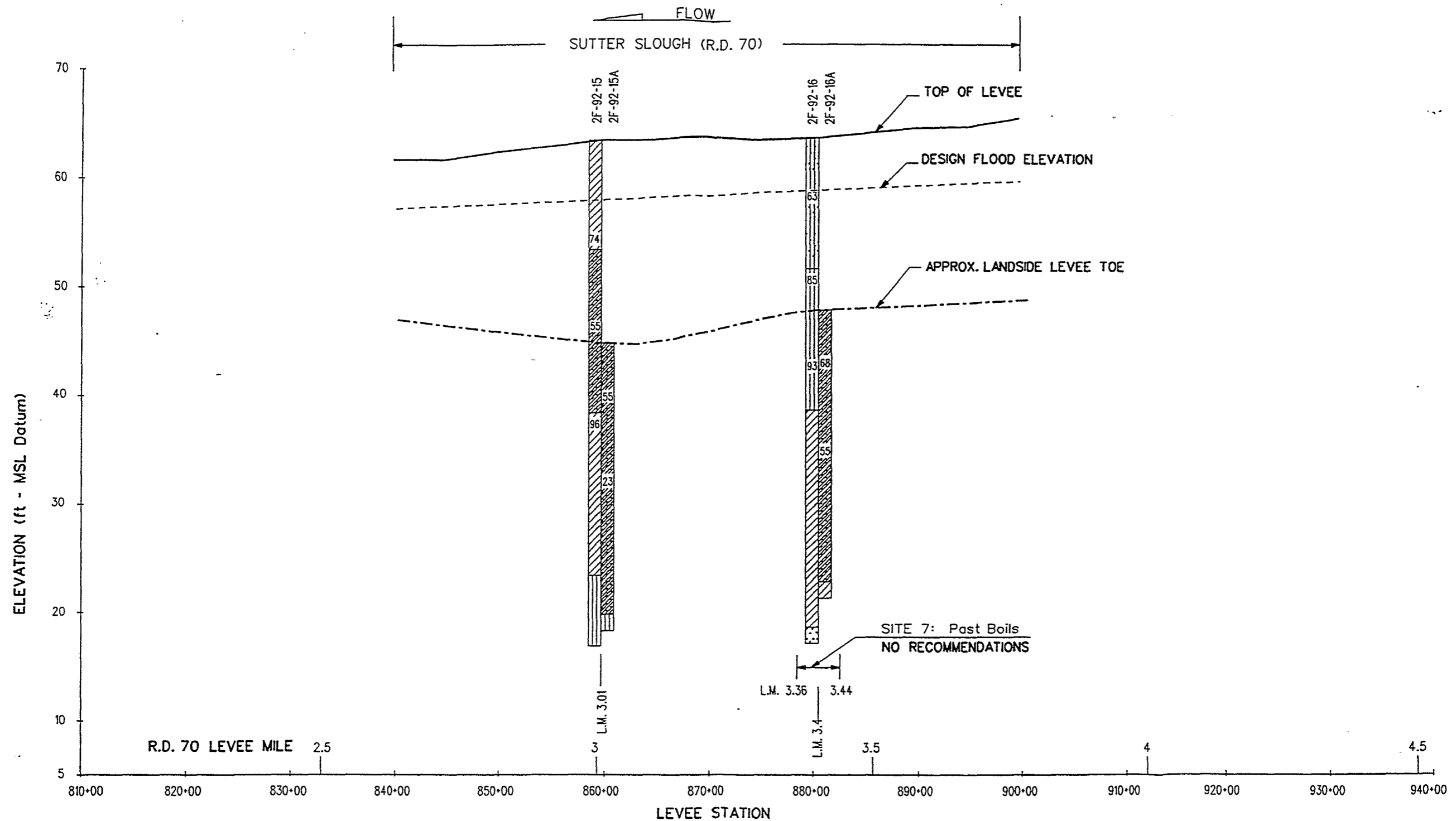
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
K. MAI K. MAI D. RICKETTS		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES CROSS SECTIONS, SUTTER BYPASS SITE 8	
DATE: Nov 30, 1982 DRAWN BY: 38 CHECKED BY: 50		FILE NO: 38 FILE NAME: PROFILES2.DGN	

SAFETY PAYS

PLATE 38

C - 1 0 3 9 3 1

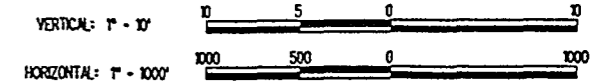
C-103931

**LEGEND**

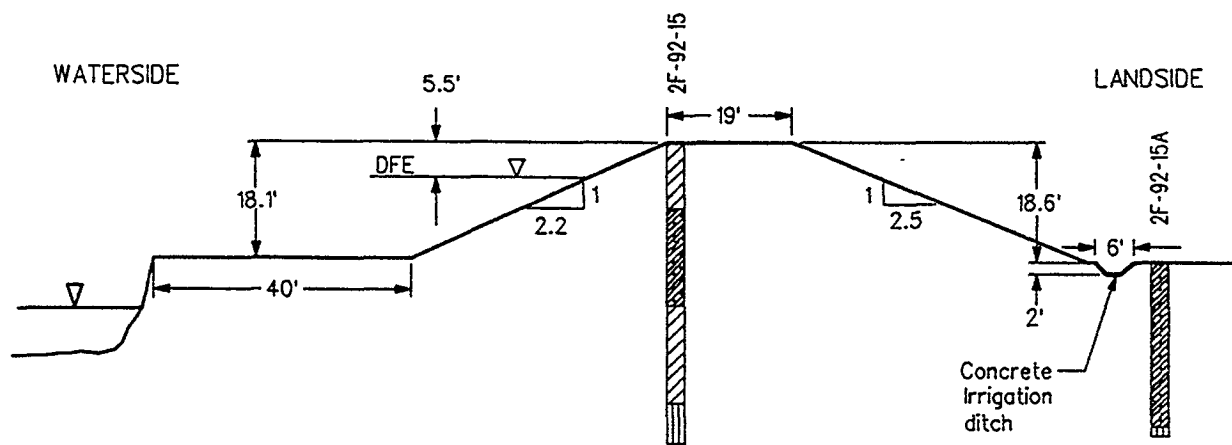
	Silt (ML, >70% fines)
	Silty sand or sandy silt (SM, 12% - 70% fines)
	Clay (CL, >70% fines)
	Clayey sand or sandy clay (SC, 12% - 70%, fines)
	Sand (SP, <12% fines)
	Percentage of fines (-200 sieve size) per laboratory testing

NOTES

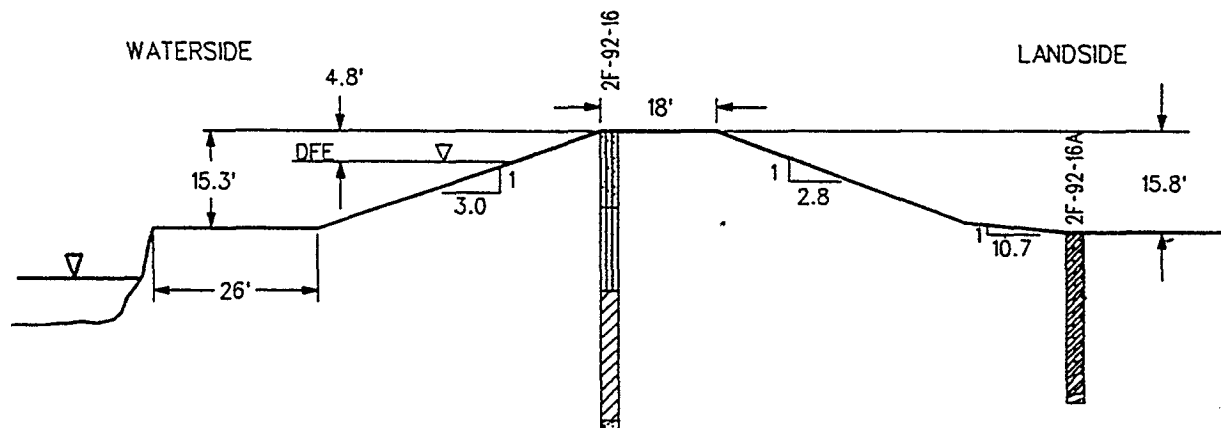
1. Soil classification are based on ECPT data - soil correlations for ECPT borings (i.e. 2F-92-*), or field descriptions and lab data for auger borings (i.e. 2F-92-*).
2. Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).

GRAPHIC SCALES

GEOTECHNICAL BRANCH		DEPARTMENT OF THE ARMY	
SOIL DESIGN SECTION		SACRAMENTO DISTRICT, CORPS OF ENGINEERS	
K. MAI		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION	
K. MAI		UPPER SACRAMENTO AREA - PHASE V	
D. RICKETTS		GEOTECHNICAL EVALUATION OF LEVEES	
		LEVEE PROFILES, SUTTER BYPASS	
		SITE 7	
DATE: AS SHOWN		NOV 30, 1992	
BY: 39		PROFILES.DGN	
50			



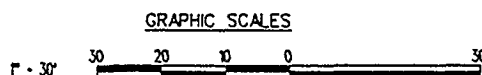
STATION 859+78 (L.M. 3.01)



STATION 879+79 (L.M. 3.40)

DFE: Design Flood Elevation

L.M.: Reclamation District 70 Levee Mile




















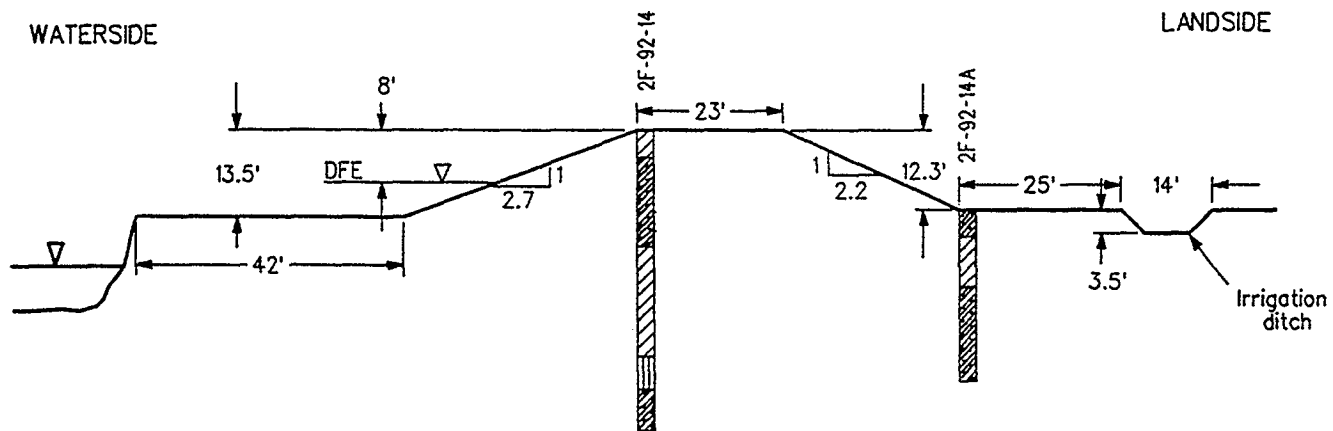
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MA	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
CHECKED BY K. MA	GEOTECHNICAL EVALUATION OF LEVEES		
DESIGNED BY D. RICKETTS	CROSS SECTIONS, SUTTER BYPASS SITE 7		
DATE Nov 30, 1992		FILE NO. PROFILES2.DGN	
DRAWN BY SOIL DESIGN SECTION		SCALE 40 50	



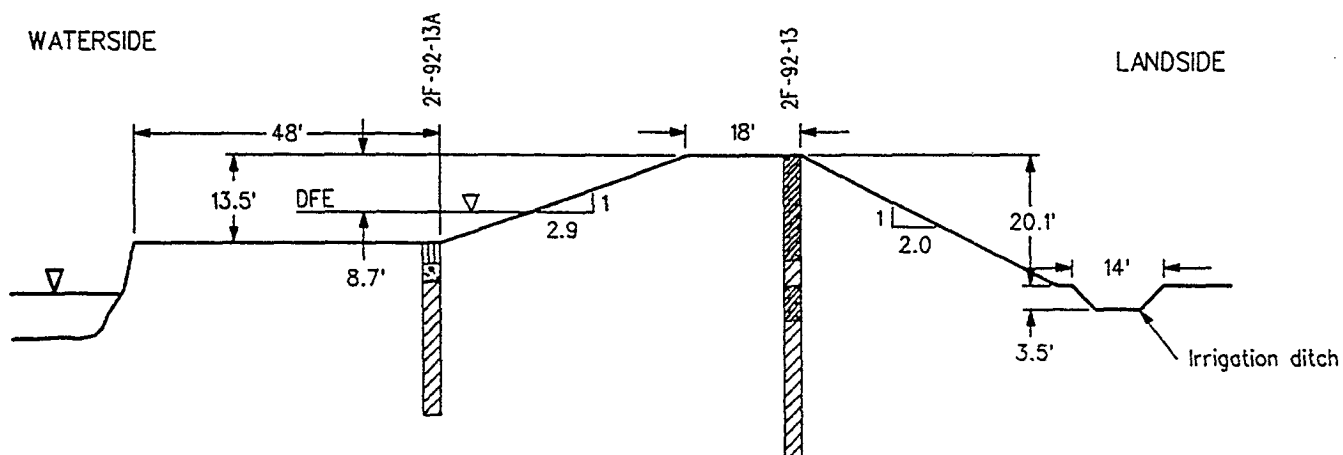
GRAPHIC SCALES

- VERTICAL: $T = 10'$
- HORIZONTAL: $T = 1000'$

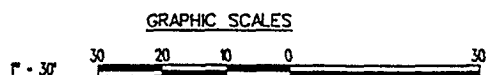


STATION 2109+43 (R.M. 134+5)



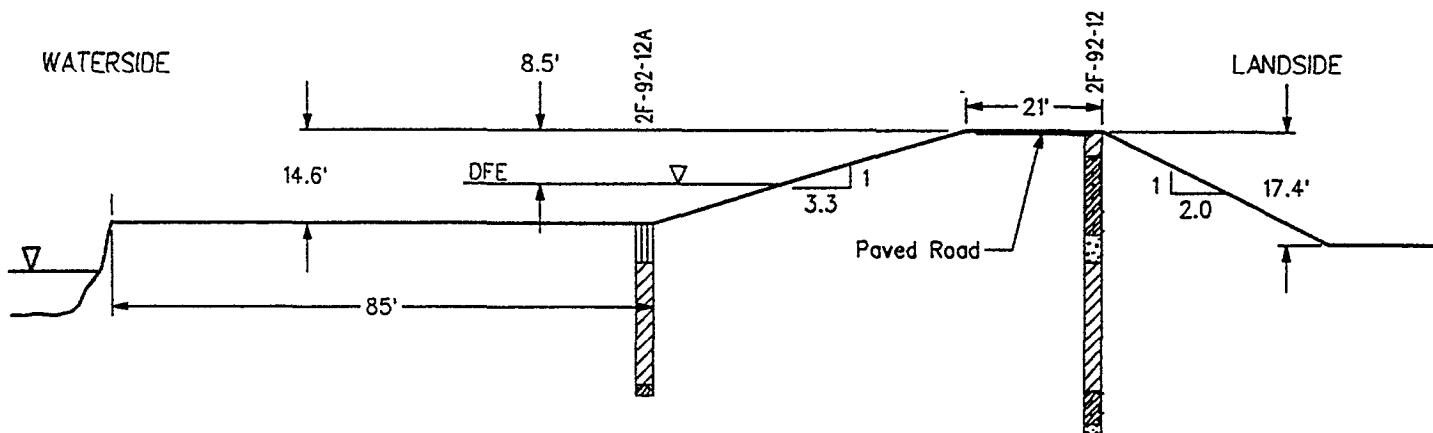
STATION 2129+44 (R.M. 134.9)

DFE: Design Flood Elevation

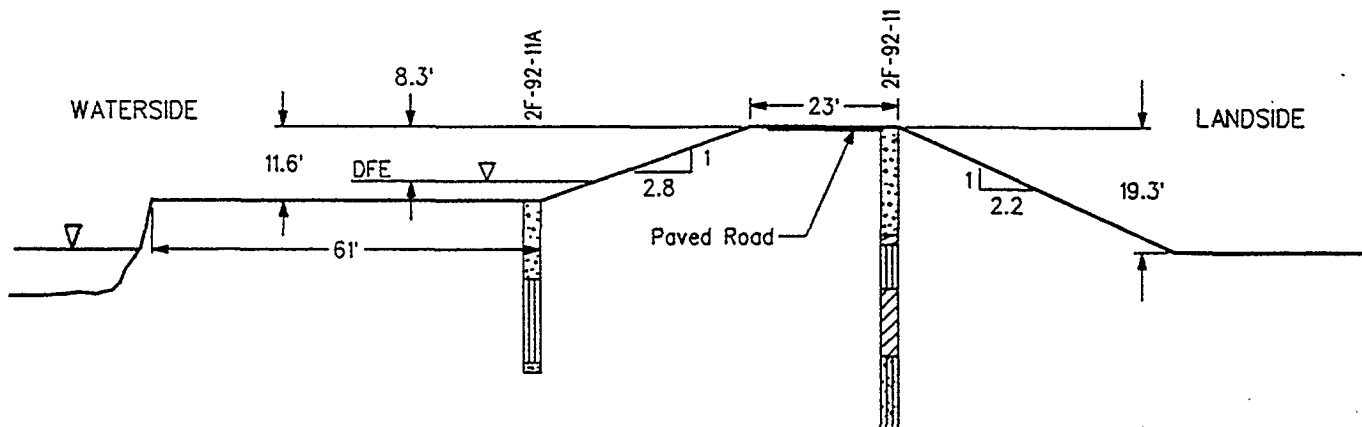


<p>GEOTECHNICAL BRANCH SOL DESIGN SECTION</p>		<p>DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA</p>	
<p>DESIGNED BY K. MA</p>		<p>SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES CROSS SECTIONS, SACRAMENTO RIVER SITE 10</p>	
<p>CHECKED BY K. MA</p>		<p>DATE AS SHOWN: May 30, 1992</p>	
<p>APPROVED BY D. RICKETTS</p>		<p>FILE NO. 42 PROFILES2.DGN</p>	

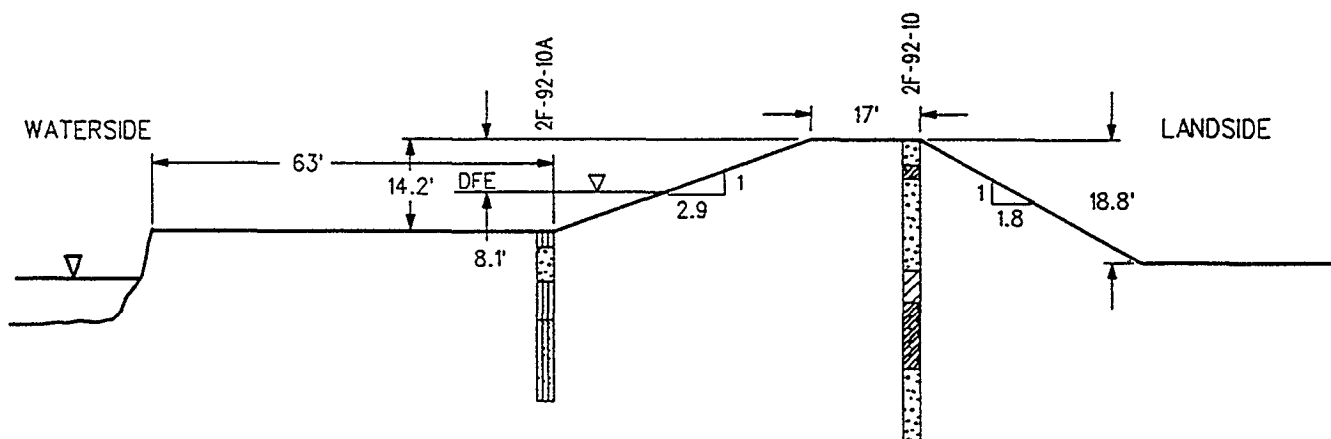




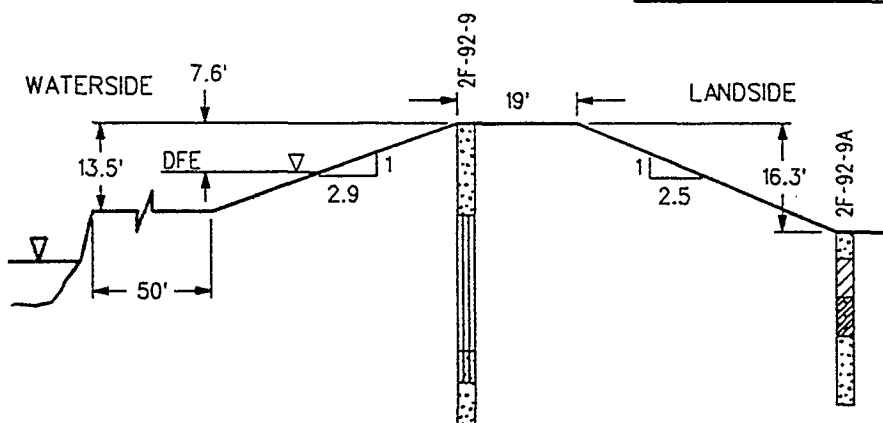
SITE 11: STATION 2391+34 (R.M. 140.3)



SITE 11: STATION 2421+28 (R.M. 140.9)



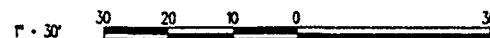
STATION 2480+12 (R.M. 141.9)



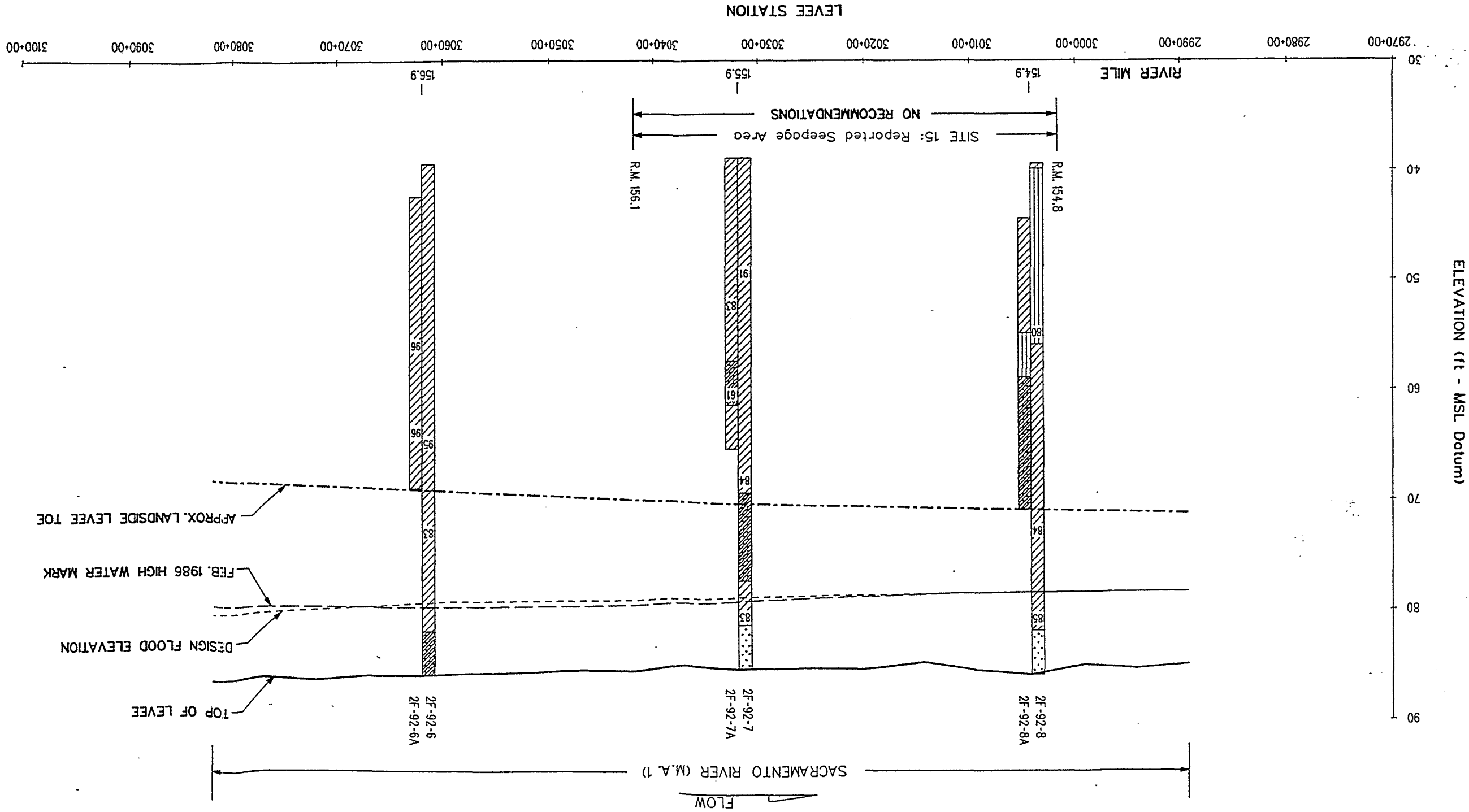
SITE 12: STATION 2528+14 (R.M. 142.9)

DFE: Design Flood Elevation

GRAPHIC SCALES



GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
K. MA K. MA D. RICKETTS		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES CROSS SECTIONS, SACRAMENTO RIVER SITE 11 & 12	
DATE: AS SHOWN 4.4 50		Nov 30, 1992 PROF ILES2.DGN	



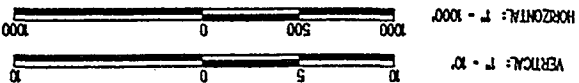
LEGEND

- Silt (ML, >70% fines)
- Silty sand or sandy silt (SM, 12% - 70% fines)
- Clay (CL, >70% fines)
- Clayey sand or sandy clay (SC, 12% - 70%, fines)
- Sand (SP, <12% fines)
- Percentage of fines (-200 sieve size) per laboratory testing

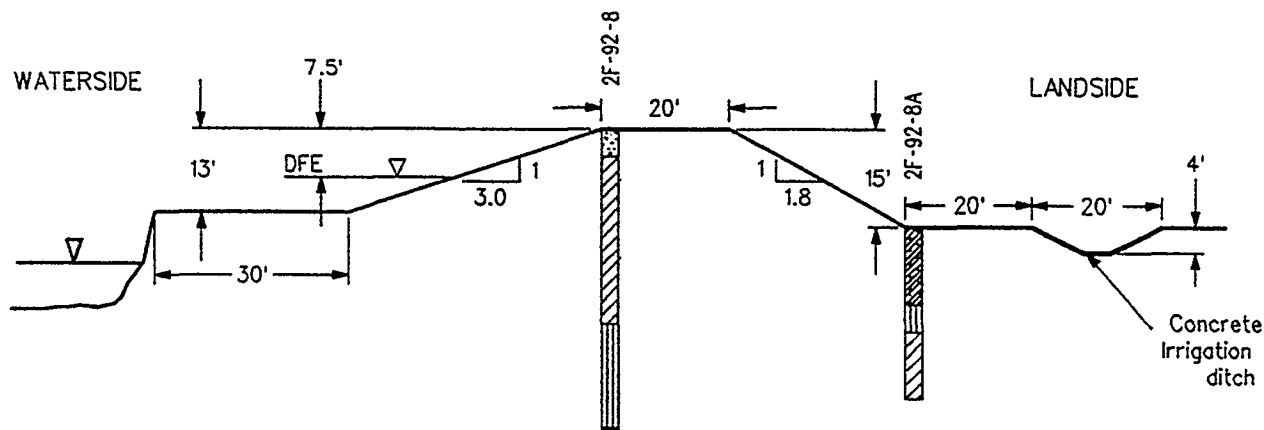
NOTES

- Soil classification are based on ECP data - soil correlations for ECP borings (i.e. 2F-92-*, or field descriptions and lab data for auger borings (i.e. 2F-92-*)
- Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).

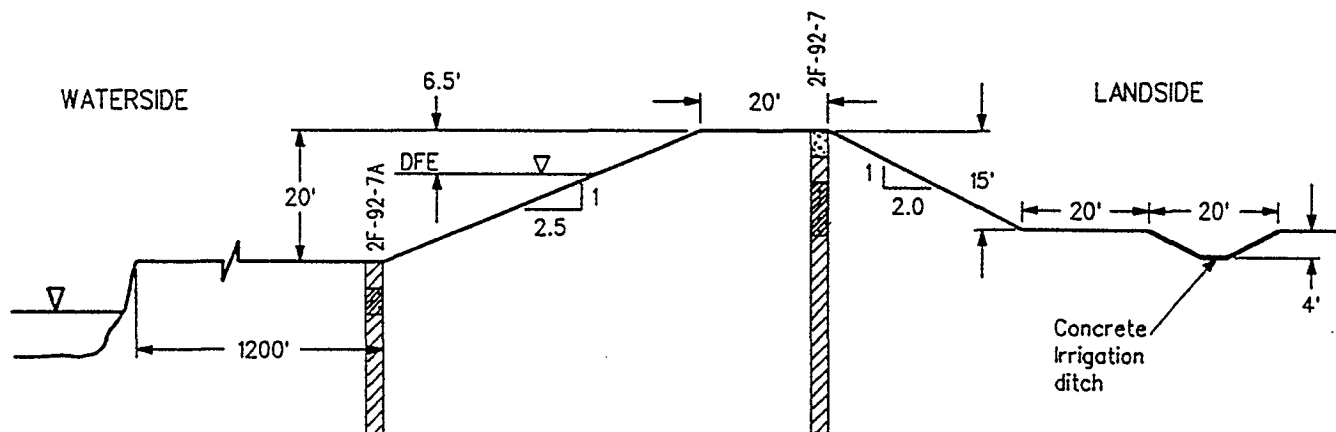
GRAPHIC SCALES



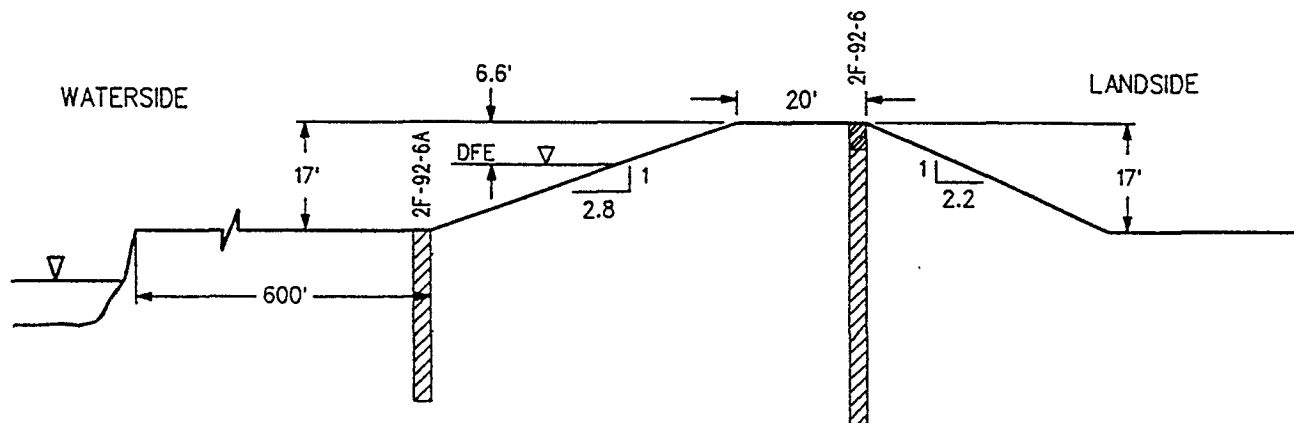
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V	
LEVEE PROFILES, SACRAMENTO RIVER	
SITE 15	
D. ROCKETTS	
K. M.A.	
K. M.A.	
SOL. DESIGN SECTION	
50	
PROFILES, DON	



STATION 3004+21 (R.M. 154.9)

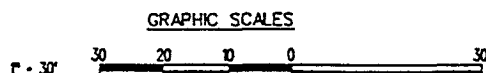


STATION 3031+89 (R.M. 155.9)

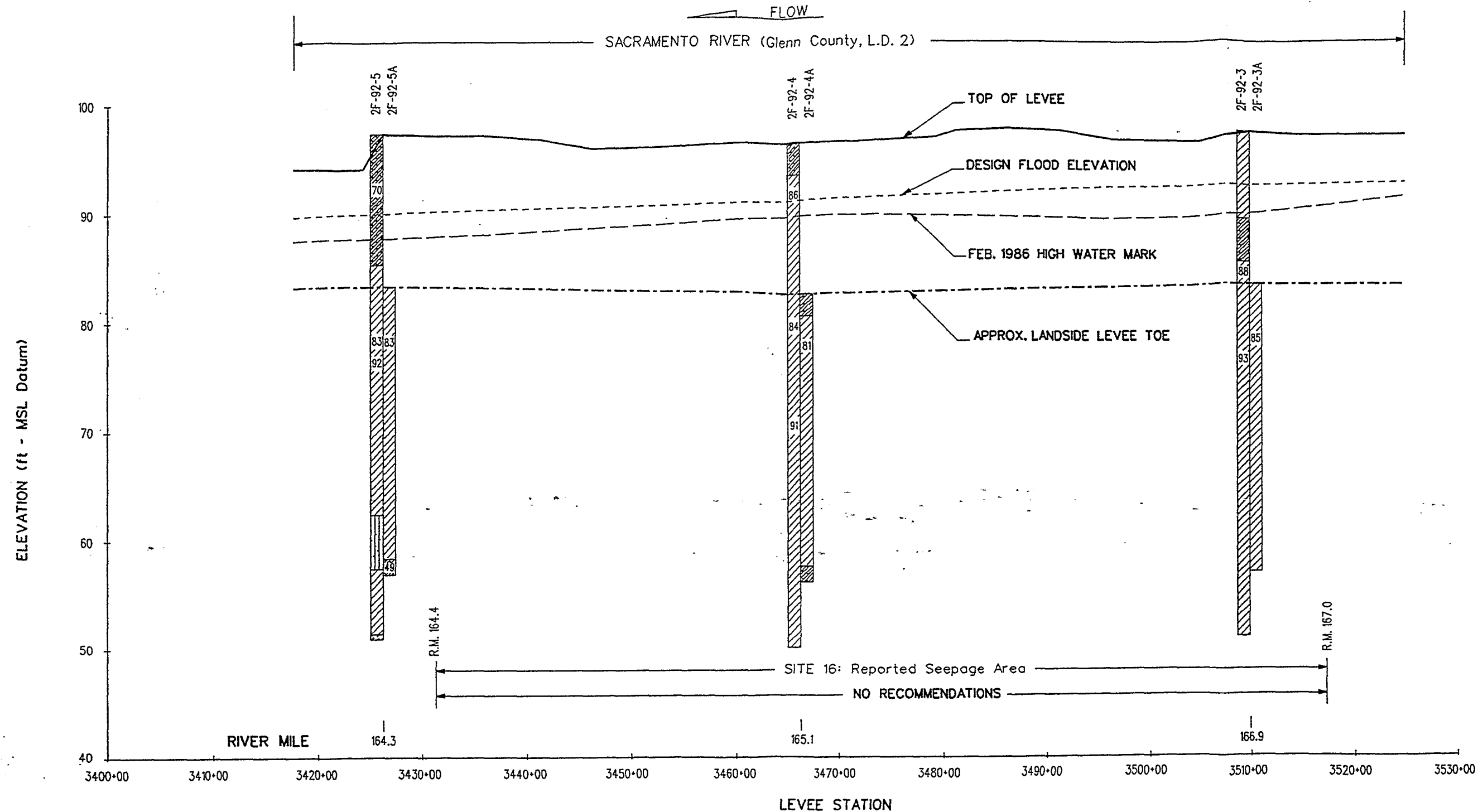


STATION 3061+92 (R.M. 156.9)

DFE: Design Flood Elevation



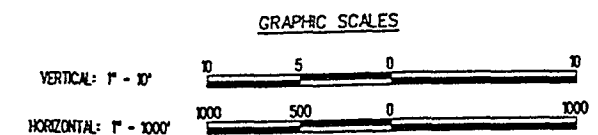
GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT OFFICE OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MA		SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V	
CHECKED BY K. MA		GEOTECHNICAL EVALUATION OF LEVEES	
DRAWN BY D. RICKETTS		CROSS SECTIONS, SACRAMENTO RIVER SITE 15	
DATE Nov 30, 1992		DRAWN BY D. RICKETTS	
SCALE AS SHOWN		FILE NO. 46	
SHEET NO. 30		PROJECT PROFILES2.DGN	

**LEGEND**

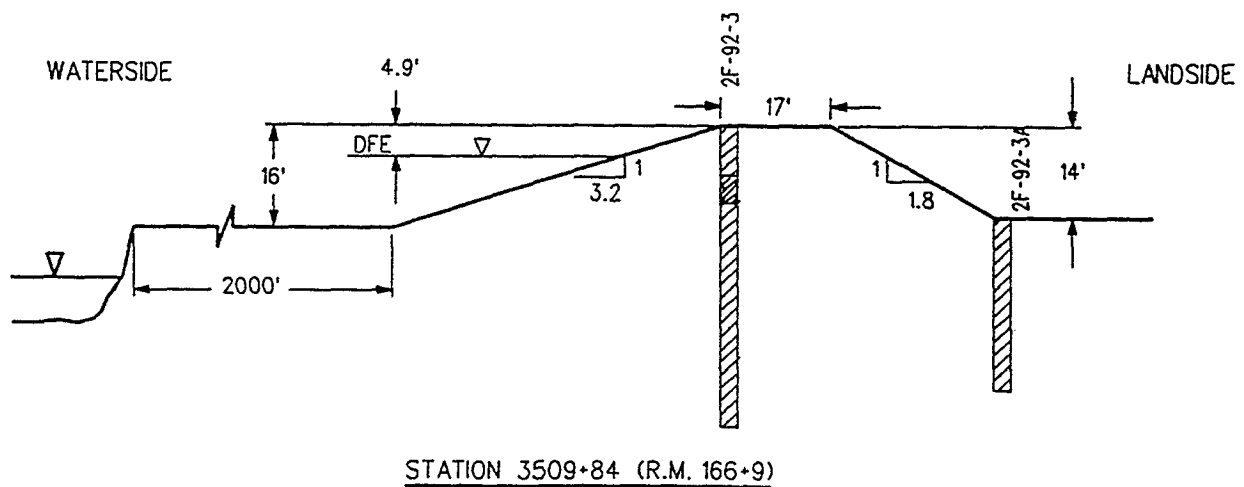
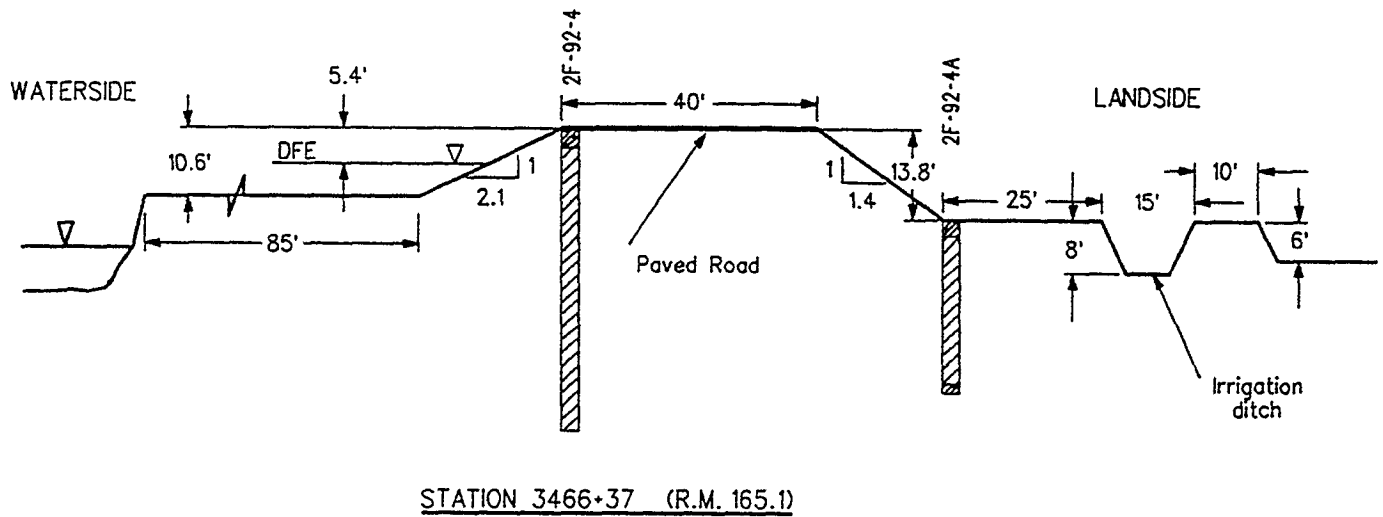
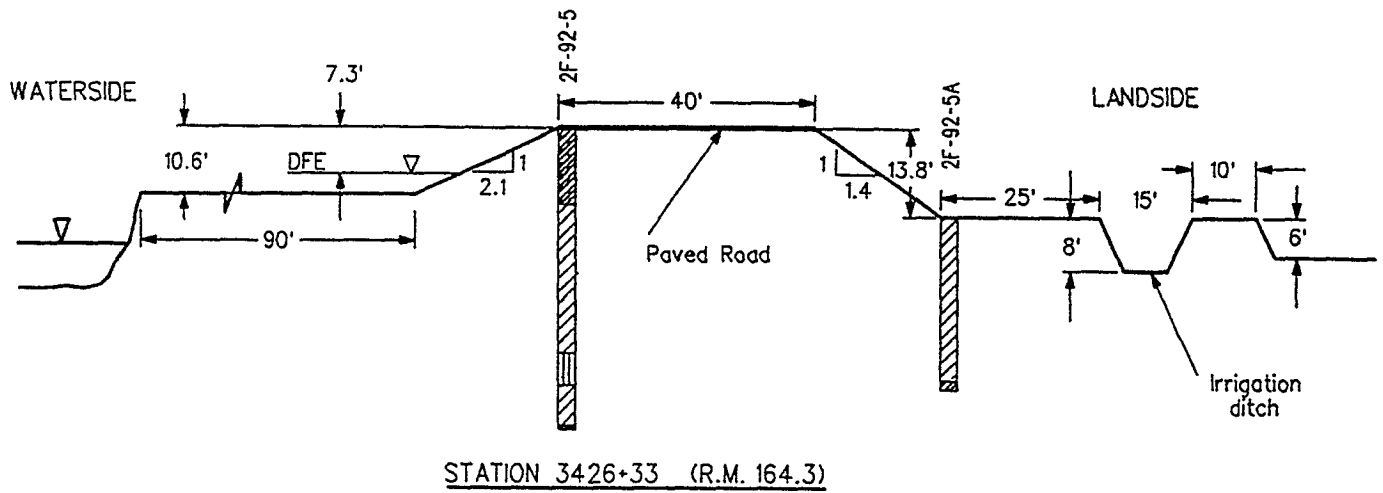
- Silt (ML, >70% fines)
- Silty sand or sandy silt (SM, 12% - 70% fines)
- Clay (CL, >70% fines)
- Clayey sand or sandy clay (SC, 12% - 70%, fines)
- Sand (SP, <12% fines)
- Percentage of fines (-200 sieve size) per laboratory testing

NOTES

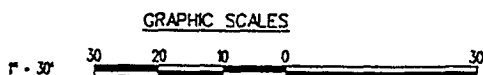
- Soil classification are based on ECPT data - soil correlations for ECPT borings (i.e. 2F-92-*), or field descriptions and lab data for auger borings (i.e. 2F-92-*)
- Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).



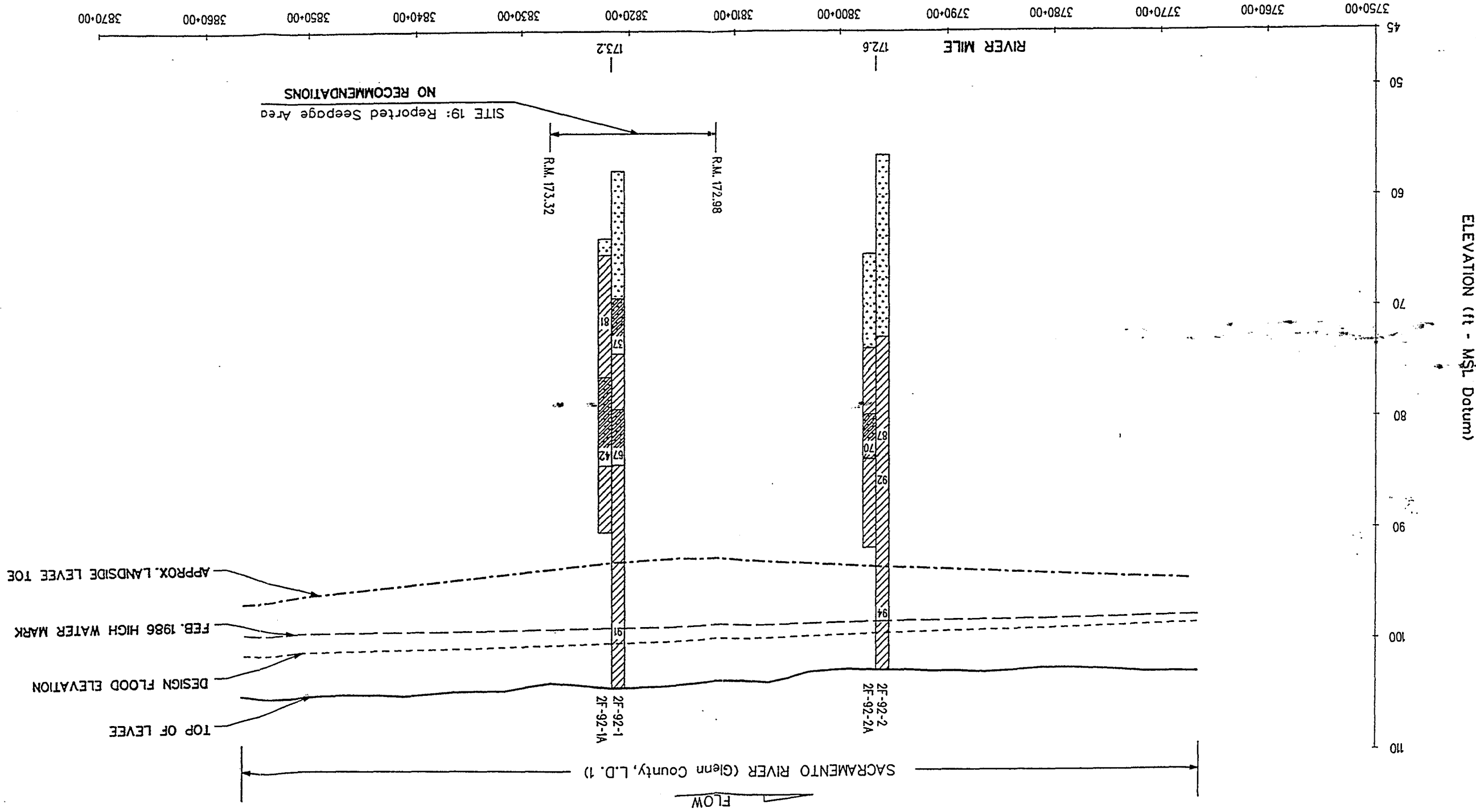
GEOTECHNICAL BRANCH		DEPARTMENT OF THE ARMY	
SOIL DESIGN SECTION		SACRAMENTO DISTRICT, CORPS OF ENGINEERS	
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION		UPPER SACRAMENTO AREA - PHASE V	
GEOTECHNICAL EVALUATION OF LEVEES		LEVEE PROFILES, SACRAMENTO RIVER	
SITE 16		Nov 30, 1992	
DESIGNED BY	AS SHOWN	47	PROFILES2.DGN
CHECKED BY	50		



DFE: Design Flood Elevation



GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAN	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V		
CHECKED BY K. MAN	GEOTECHNICAL EVALUATION OF LEVEES		
DRAWN BY D. RICKETTS	CROSS SECTIONS, SACRAMENTO RIVER SITE 16		
DATE Nov 30, 1992		PROJ FILE NO. PROF1LES2.DGN	



LEGEND

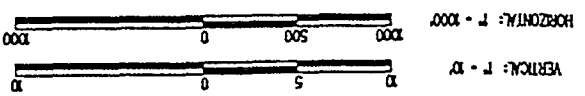
- Silt (ML, >70% fines)
 - Silty sand or sandy silt (SM, 12% - 70% fines)
 - Clay (CL, >70% fines)
 - Clayey sand or sandy clay (SC, 12% - 70% fines)
 - Sand (SP, <12% fines)
- Percentage of fines (<200 sieve size) per laboratory testing

NOTES

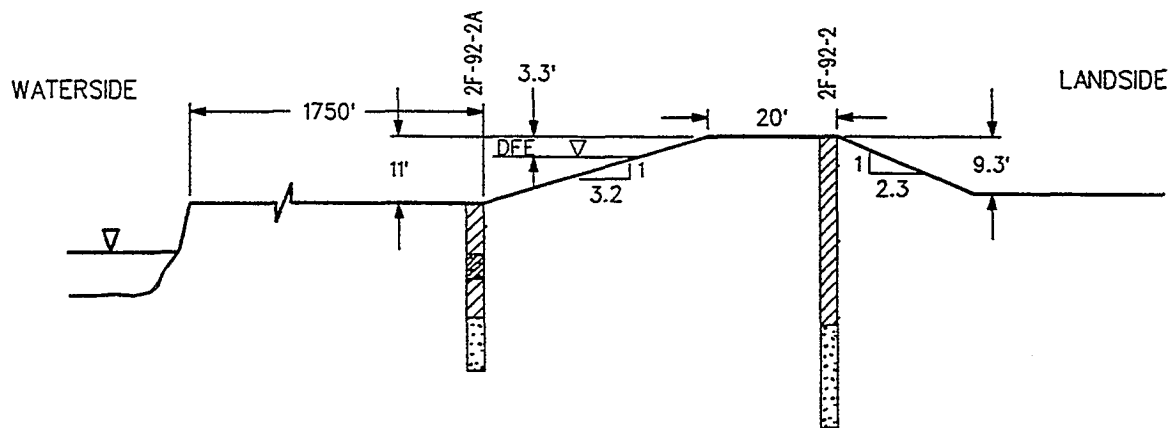
- Soil classification are based on ECP data - soil correlations for ECP borings (i.e. 2F-92-*,), or field descriptions and lab data for auger borings (i.e. 2F-92-*)
- Where laboratory classification data is available, soil legend generally conforms to ASTM D2487 except that no distinction is made between silt and silt with sand or between clay and clay with sand. For the purpose of this study, all sand deposits with less than 12% fines content are indicated as clean (high susceptibility to seepage and piping).

LEVEL STATION

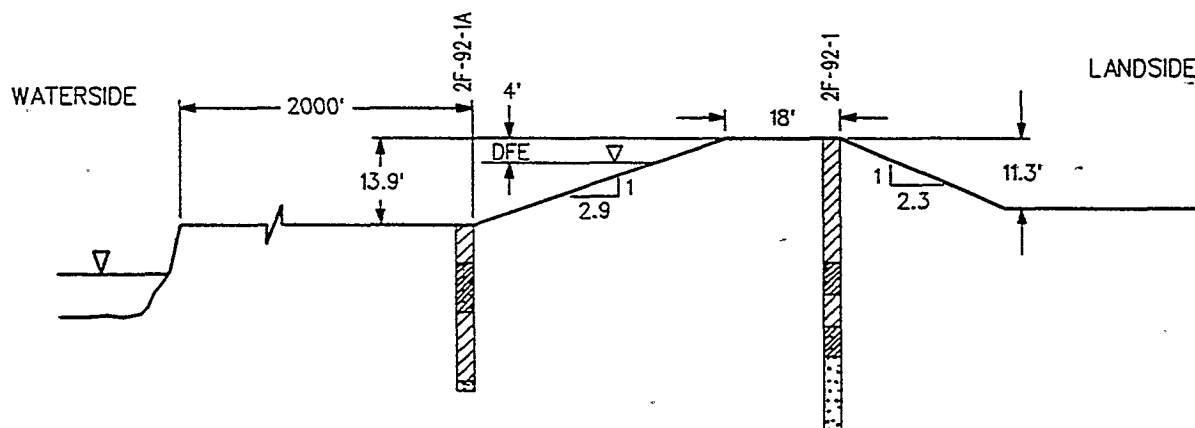
GRAPHIC SCALES



DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT OFFICE SACRAMENTO, CALIFORNIA	
GEOTECHNICAL BRANCH SOIL DESIGN SECTION	
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE A	
GEOTECHNICAL EVALUATION OF LEVEES LEVEL PROFILES, SACRAMENTO RIVER	
SITE 19	
DATE AS SHOWN MAY 30, 1992	
PROJECT NO. 30	
DRAWN BY: [Signature]	

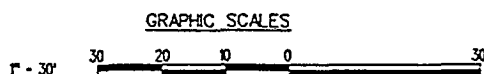


STATION 3796+79 (R.M. 172.6)



STATION 3821+79 (R.M. 173.2)

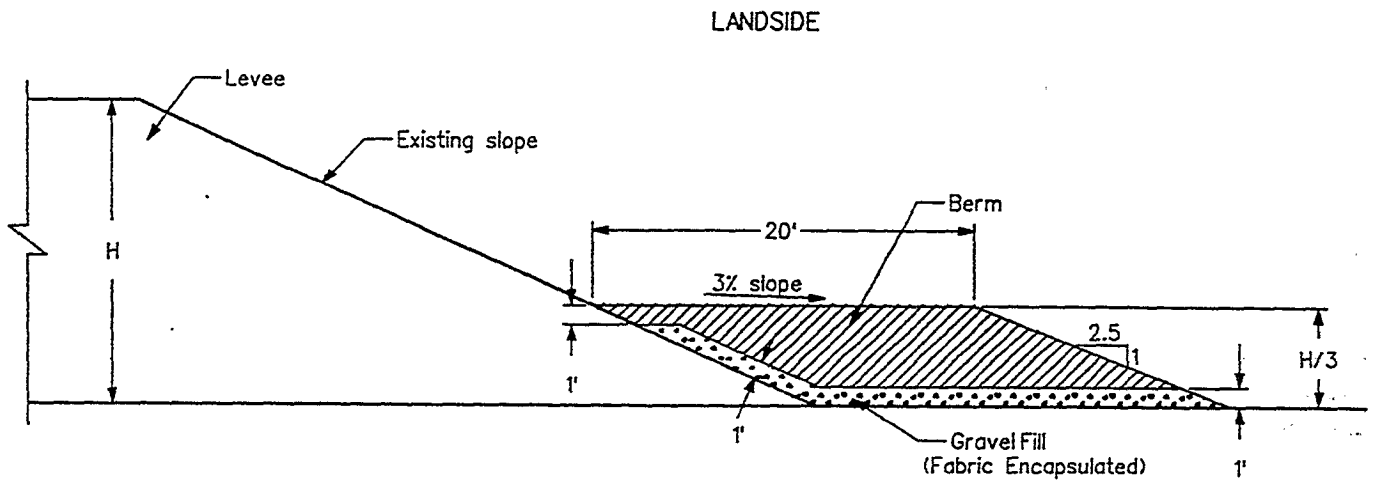
DFE: Design Flood Elevation



GEOTECHNICAL BRANCH SOIL DESIGN SECTION		DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY K. MAN	SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V GEOTECHNICAL EVALUATION OF LEVEES CROSS SECTIONS, SACRAMENTO RIVER SITE 19		
CHECKED BY K. MAN			
DESIGNED BY D. RICKETTS			
DRAWN BY (blank)	SCALE AS SHOWN 50 50	DATE Nov. 30, 1992	FILE NO. PROFILES2.DGN

**BASIS OF DESIGN
GEOTECHNICAL EVALUATION OF LEVEES
FOR
SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION
UPPER SACRAMENTO AREA - PHASE V**

**APPENDIX A
ALTERNATIVE REPAIR SCHEMES**



SEEPAGE/STABILITY BERM

(Site 4. and 11 /12)

GRAPHIC SCALES



<p>GEOTECHNICAL BRANCH SOIL DESIGN SECTION</p>		<p>DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA</p>	
<p>DESIGNED BY K. MA</p>		<p>SACRAMENTO RIVER FLOOD CONTROL SYSTEM EVALUATION UPPER SACRAMENTO AREA - PHASE V</p>	
<p>CHECKED BY K. MA</p>		<p>GEOTECHNICAL EVALUATION OF LEVEES</p>	
<p>APPROVED BY D. RICKETTS</p>		<p>SEEPAGE/STABILITY BERM</p>	
<p>DATE Jan 30, 1982</p>		<p>REVISION 1</p>	
<p>PROJECT NO. C-103945</p>		<p>PROFILES2.DGN</p>	

SAFETY PAYS

A-1

C-103945

C-103945